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No. 504

COMPLETE TANK TESTS OF TWO FLYING-BOAT HULLS WITH POINTED STEPS - N.A.C.A. MODELS 22-A and 35

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SUMMARY

This note presents the results of complete tank tests of N.A.C.A. Models 22-A and 35, two flying-boat hulls of the deep pointed-step type with low dead rise. Model 22-A is a form derived by modification of Model 22, the test results of which are given in N.A.C.A. Technical Note No. 488. Model 35 is a form of the same type but has a higher length-beam ratio than either Model 22 or 22-A.

Take-off examples are worked out using data from these tests and a previous test of a conventional model applied to an arbitrary set of design specifications for a 15,000-pound flying boat. The comparison of these examples shows both pointed-step models to be superior to the conventional form, and Model 35 to be the better of the two.

Model 35 is applied to a hypothetical 100,000-pound flying boat of the twin-hull type and performance calculations are made both for take-off and range. The results indicate that the high performance of this type of hull will enable the designer to use higher wing and power loadings than are found in current practice, with a resulting increase in range and pay load.

INTRODUCTION

The water characteristics of a flying-boat hull of the pointed-step type, N.A.C.A. Model 22, are presented in reference 1. The form of that hull was developed as a result of observations of the behavior of conventional hulls running at high speeds and light loads. The type was expected to have low resistance in the high-speed range, without a corresponding increase in hump resistance. The results presented in reference 1 show that the low resistance at high speeds was realized, but that the hump resistance for a given load coefficient was somewhat higher than that of a good conventional hull. The remedy for this undesirable condition appeared to consist of altering the forebody of Model 22, to give a longer flat on the forebody planing bottom. The tests of Model 22 also showed that a pronounced roach, or feather, was formed aft of the sternpost at certain speeds. The addition of a tail extension suitable for supporting the aerodynamic control surfaces was expected to suppress this roach. Model 22 was modified according to these ideas, and the resulting form was designated Model 22-A.

The results of the tests on Model 22 indicated that the type offered sufficient promise to warrant the application of the pointed step to a hull of higher length-beam ratio, suitable for use on a single-float seaplane or a twin-hull flying boat. N.A.C.A. Model 35, having a length-beam ratio of 6.15, was designed for this purpose.

Tests of these two models were made in the N.A.C.A. tank during November and December, 1933. The complete type of test was used in this investigation, in order to obtain design data suitable for seaplanes having a wide range of gross loads and get-away speeds.

APPARATUS AND METHODS

The N.A.C.A. tank and associated equipment are discussed in detail in reference 2. The apparatus used in making the present tests was as described except for a change in the method of suspending the towing gear. This change will be discussed in a future report.

The complete method discussed in reference 3 was used in making the present tests. The procedure is to tow the model at a series of loads, speeds, and trim angles selected to include any combination of these variables at which the hull may operate. The resistance, trimming moment, speed, and draft of the step were measured for each test point.

An unusually wide range of loads was used in testing Model 35 in order to reach the high load coefficients at which the model would operate if applied to a float seaplane or a twin-hull flying boat. The high length-beam ratio of Model 35 makes it applicable to these types as well as to the conventional single-hull flying boat.

DESCRIPTION OF MODELS

Model 22-A was derived from Model 22, which is described in reference 1. The changes made in 22 to form 22-A can best be seen by comparing the lines of the two models shown in figure 1. The forebody was lengthened 5.7 percent over that of 22 and the bow was made lower, reducing the curved portion of the buttocks and thus making the straight portion of the buttocks extend much farther forward of the step than in Model 22. A tail extension of the type used principally for supporting the aerodynamic control surfaces was added to 22-A. The maximum beam, step depth, angle of dead rise, and afterbody shape, exclusive of the tail extension, are the same as in Model 22.

The lines of Model 35 are shown in figure 2. Model 35, like 22-A, has a deep pointed step, a horizontal afterbody, and a low angle of dead rise. The principal differences from 22-A are a greater length-beam ratio, a slightly longer forebody, and a 5° increase in the angle of dead rise. The high length-beam ratio makes this model applicable to float seaplanes and twin-hull flying boats, as well as to conventional single-hull flying boats. Model 35 was made without a tail extension aft of the sternpost because its effect on the performance of Model 22-A had been slight. These lines may be used as theyare in a design carrying the tail surfaces on outriggers, or with an added tail extension for a design carrying the surfaces on the hull structure.

Both models were made of laminated mahogany and covered with plywood decks. The surface was finished with several coats of grey enamel rubbed smooth.

The principal dimensions of Models 22, 22-A, and 35 are:

Model	22	22-A	35
Length over-all, including tail extension, inches	--	98.75	--
Length from bow to afterbody sternpost, inches	76	78.75	80
Maximum beam, inches	17	17	13
Depth over-all, inches	12	12	11
Depth of step, inches	2.94	2.94	2.94
Angle of dead rise, degrees	10	10	15
Angle between keels, degrees	0	0	0

Complete offsets of Models 22-A and 35 are given in tables I and II, respectively.

RESULTS

Test data.- Tables III and IV give the speeds, resistance, trim angles, drafts, and trimming moments of Models 22-A and 35 obtained directly from observed data by deducting the usual tares as discussed in reference 3. The same data, with the exception of drafts, are given graphically in figures 3 to 8 for Model 22-A, and figures 16 to 20 for Model 35. Each figure represents the data for one trim angle, giving resistance and trimming moment plotted against speed with the load on the water as the parameter.

All moments are measured about the centers of moments of the respective models as located in figures 1 and 2. The measured moments must be transferred to the actual center of gravity of any design to which the data are applied. Moments that tend to raise the bow are considered positive.

The trimming moments and drafts at rest are given in figures 9 and 10 for Model 22-A and figures 21 and 22 for

Model 35. These curves may be used to determine the water line at rest for any load and center-of-gravity position. The trimming-moment curves also give the longitudinal righting moments of the hull at rest.

Nondimensional results.- The number of independent variables in the test data makes their application to design difficult. A method of avoiding the difficulties and reducing the number of variables is discussed in reference 3. The procedure consists of determining the minimum resistance and best trim angle for each speed and load by plotting resistance against trim angle for the given speed with the load on the water as a parameter. Curves of minimum resistance and best trim angle are then plotted against load for each speed. The results are reduced to nondimensional form and plotted as curves of best trim angle and resistance coefficient at best trim angles against speed coefficient with load coefficient as a parameter. Trimming moments at best trim angles are determined by plotting trimming moments against trim angles for a given speed and load and reading the moment corresponding to the best trim angle from the curve. The results are reduced to nondimensional coefficients and plotted as moment coefficient for best trim angle against speed coefficient with the load coefficient as a parameter.

The nondimensional coefficients are defined as follows:

Load coefficient $C_\Delta = \dfrac{\Delta}{wb^3}$

Resistance coefficient $C_R = \dfrac{R}{wb^3}$

Trimming-moment coefficient $C_M = \dfrac{M}{wb^4}$

Speed coefficient $C_V = \dfrac{V}{\sqrt{gb}}$

where Δ is the load on the water, lb.

R is resistance, lb.

w is weight density of water, lb./cu.ft.

b is beam of hull, ft.

M is trimming moment, lb.-ft.

V is speed, ft./sec.

g is acceleration of gravity, ft./sec.^{2}

Note: w = 63.5 lb./cu.ft. for water in the N.A.C.A. tank.

Nondimensional results are given graphically for Model 22-A in figures 11 to 15 and for Model 35 in figures 23 to 27.

Precision.- The test results presented in the faired curves are believed to be accurate within the following limits:

Load	±0.3 lb.
Resistance	±0.1 lb.
Speed	±0.1 ft./sec.
Trim angle	±0.1°
Trimming moment	±1 lb.-ft.

DISCUSSION

Resistance characteristics.- The resistance of both Models 22-A and 35 was unusually low for all speeds and loads. The curves of resistance coefficient at the best trim angles against speed coefficient for Model 22-A (fig. 12) show that the increase of resistance with speed in the high speed range is considerably less than that of a conventional hull. (See reference 4.) The improvement at hump speed in the ratio of load to resistance effected by altering the forebody of Model 22 may be seen from the comparison of the curves of Δ/R against C_Δ for Models 22 and 22-A in figure 15. At high speeds the resistance of Model 22-A was somewhat higher than that of Model 22, although the form of the planing bottom actually in contact with the water at these speeds was the same in both cases. This increase is probably caused in part by the higher air drag of the modified model.

The resistance characteristics of Model 35 are shown by the curves of C_R against C_V in figure 24 and Δ/R

against C_Δ in figure 27. At hump speed the resistance of this model for load coefficients in the range ordinarily used for flying-boat hulls (0.4 to 0.6) is considerably lower than that of any other hull tested in the N.A.C.A. tank to-date. The resistance at given values of the speed and load coefficients in the high speed range is lower than that of a conventional hull (see reference 4) but somewhat higher than that of Model 22-A. At a load coefficient of 1.2, which is within the range of loading generally used for single-float seaplanes, the value of Δ/R at the hump for Model 35 is about 4.5. Good conventional floats usually have somewhat smaller ratio of load to resistance at the hump.

Moment characteristics.- The curves of moment coefficient against speed coefficient for both Models 22-A and 35, (figs. 14 and 26) show a pronounced positive moment at speeds somewhat above the hump. In some cases the moment may be great enough to prevent the pilot's maintaining the best trim angle in this region. The resistance in this range is not ordinarily critical, however, and a small deviation from the best trim angle would not cause a serious increase of take-off time or run. Throughout the other parts of the speed range the moments at best trim angles are low and can probably be controlled satisfactorily. An exception to this statement may be noted in figure 14. The moment coefficients for Model 22-A at load coefficients of 0.5 and 0.6 show rather large negative values at the hump speed. If load coefficients in this range are used in a flying-boat design, the center of gravity should probably be placed farther aft than the center of moments shown in figure 1, so that the best trim angle may be held at the hump speed.

Spray formation.- Neither of the models showed objectionable spray characteristics. The bow blisters were relatively low, probably because of the low dead-rise angles. The addition of the tail extension on Model 22-A served to suppress the roach formed at low speeds and heavy loads. The roach was present in the case of Model 35, but could probably be controlled in the same manner if the form were applied to a flying-boat design. In the case of a seaplane float there is, of course, no means of suppressing this roach. The wake of Model 35, however, was substantially the same as that of a conventional seaplane float having a pointed stern; hence, the usual clearance provided to keep the tail surfaces out of the roach at low speeds should be sufficient.

General behavior.- No definite information on the porpoising characteristics of the pointed-step hulls is obtainable from the resistance tests. The construction of special apparatus for the study of porpoising in the N.A.C.A. tank is contemplated, and the relative behavior of various types of hulls will be determined as soon as this equipment is available. Although there is no reason to expect undesirable porpoising from either Model 22-A or 35, quantitative data on this point can only be furnished by future tank tests with the special apparatus, or by full-scale experiments.

Some tendency toward directional instability, extending over a small range of low speeds, was noted in reference 1 for Model 22. The same characteristic was observed in Models 22-A and 35. Although it is unlikely that this instability would cause trouble in an actual seaplane, an attempt was made to reduce it by fitting spray strips to the forebody chine just aft of the point of maximum beam. The strips used were 3/16 inch (1.4 percent of the beam) in width and projected from the chine at an angle of 30° below the horizontal. They extended longitudinally from a point 45 percent of the forebody length to a point 80 percent of the forebody length from the bow. The strips reduced the tendency toward directional instability, apparently by allowing the curved sides of the forebody to run dry at a lower speed. The effect on the resistance and trimming moment was small. Some of the instability, apparently arising from the flow over the curved sides of the afterbody at low speeds and heavy loads, persisted after the addition of the spray strips. This characteristic has also been observed in conventional hulls having pointed afterbodies, and could probably be controlled by the addition of spray strips forward of the sternpost if the condition were troublesome.

Take-off examples.- Although the relative resistance of various hulls can be compared in a general way by means of the curves of Δ/R plotted against C_Δ (figs. 15 and 27), the comparison is somewhat obscured when hulls of different length-beam ratios are being considered. The curves give a direct comparison on the basis of equal beams for a given load. Model 35, however, would ordinarily have a narrower beam for a given application than a hull of lower length-beam ratio, both because the best compromise between the hump and high-speed resistance requires a smaller beam, and because the weight of the longer hull would be excessive if the beams were made equal. Actual take-off calculations offer a better basis of comparison; hence, several examples are included here.

The first set of examples compares the performance of Models 22-A and 35 with that of a hull of the conventional American type, Model 11-A (reference 4), applied to a hypothetical flying boat. The design data assumed are the same as those used in the examples in references 3 and 4:

Gross load	15,000 lb.
Wing area	1,000 sq. ft.
Power	1,000 hp.
Effective aspect ratio, considering ground effect	7.0
Parasite drag coefficient, excluding hull	0.05
Airfoil	Clark Y

The method of calculating the take-off performance from complete tank test data is described in detail in reference 3; hence, only the results of the calculations will be given. The method of selecting the beam of a hull of given form, outlined in that reference, is not entirely satisfactory for Model 22-A. The method consists of choosing the beam so that the margin of thrust in the high-speed range is approximately the same as that at the hump. The unusually low resistance at high speeds of this model permits the use of an excessively large beam, without serious reduction of excess thrust near get-away. The resulting water resistance is low throughout the take-off, but the weight and air drag of the hull are unnecessarily large. For these examples it was therefore decided to select the beams for the various forms so as to give approximately equal weights for the three hulls, which was done by making the product of the beam times the length from the bow to the afterbody sternpost the same in the three cases. The beam used for Model 11-A (reference 4) was determined for the same design conditions as 8.07 feet. The length corresponding to this beam is 36.0 feet from the bow to the afterbody sternpost.

The curves of air drag, total resistance, and propeller thrust for the three cases are shown in figure 28. The thrust curve is that used in the example in reference 3. The excess thrust shown in figure 28 was used to calculate the curves of $1/a$ and V/a (where a is the acceleration and V the speed) shown in figures 29 and 30, in the manner described in reference 3. The take-off time for each case is given by the area under the $1/a$ curve and the run by the area under the V/a curve. It should be noted that the get-away speed indicated by extrapolation of the angle-of-attack curve was not exactly the same for the three cases. All three were assumed to be taken off at 103 feet per second by means of a slight pull-up at get-away.

A summary of the take-off performance of the three hulls is given in the following table:

Model	11-A	22-A	35
Beam, ft.	8.07	7.92	6.87
Length (to afterbody sternpost), ft.	36.0	36.7	42.3
Initial C_Δ	0.445	0.471	0.723
Wing setting, degrees	6.7	6.1	4.4
Take-off time, sec.	38.0	33.6	31.5
Take-off run, ft.	2,410	1,920	1,860

The foregoing comparison shows that a hull of the pointed-step type with low dead rise may give a considerably shorter take-off than a conventional hull, when applied to the same seaplane design. The importance of high-performance hulls in general, however, lies in their ability to take off with abnormally high wing and power loadings, thus permitting the design of seaplanes having a larger range and/or pay load than those now in use. In order to show the possibilities of such a design, the test data for Model 35 will be applied to a hypothetical twin-hull flying boat of 100,000 pounds gross load. In order to obtain the full advantage of the good performance of this model, the wing and power loading should both be made large, and the parasite drag reduced to a minimum. Such a design will have a high ratio of useful load, together with a reasonably fast cruising speed at low fuel consumption.

The aspect ratio can be rather low in order to save structural weight, since the induced drag is of primary importance only in climb - a minor consideration for a long-range flying boat.

An outline drawing of the hypothetical flying boat used in this example is shown in figure 31. The engines are housed within the wing and drive through the leading edge. The cooling system should be of the vapor type, using the wing surface for radiation. This arrangement seems to be feasible in the light of present knowledge, and is necessary to reduce the cruising drag to a point where non-stop transoceanic flights can be made with reasonable pay load.

The essential design data used in this example are as follows:

Gross weight	100,000 lb
Wing area	4,000 sq. ft.
Total power (eight engines of 625 hp.)	5,000 hp.
Aspect ratio	4.5
Airfoil	N.A.C.A. 4315 (data taken from N.A.C.A. T.R. No. 460)

The lift and drag curves assumed for this flying boat are shown in figure 32. It should be noted that the ground effect with a water clearance of 15 feet and a span of 135 feet, calculated by the method given in reference 5, increases the effective aspect ratio for take-off to 8.3. The beam of each of the two hulls was chosen as 10.92 feet, corresponding to a load coefficient of 0.55 and a load-resistance ratio of 6.5 at the hump speed. The angle of wing setting, determined by the method outlined in reference 3, was 6.8°. In the take-off calculation, however, a wing setting of 5° was used, since the resulting take-off performance is only slightly worse, and the air drag of the hulls at cruising speed would be somewhat less.

The curves of thrust and total resistance for the take-off example are shown in figure 33. Two thrust curves are shown. The lower one is based on eight engines of 625 hp. each, driving fixed-pitch propellers designed for 1,800 r.p.m. at top speed. The other was calculated for the same engines driving controllable propellers at 1,500 r.p.m. The propeller data were taken from figure 6 of reference 6. Although the tests were made with the propeller in front of a completely cowled radial engine, they probably apply fairly well to an installation such as that assumed in this example.

The curves of $1/a$ and V/a calculated from the curves of figure 33 (using the thrust for controllable propellers) are shown in figure 34. Integration of the areas under the curves shows the take-off time with no wind to be 64 seconds and the run 5,230 feet. The high power loading causes the take-off to be relatively long, in spite of the fact that the excess thrust is large compared to the total resistance.

As a matter of interest the range of this hypothetical flying boat was calculated by the method given in reference 7. Controllable propellers were assumed in this calculation, and enough engines cut out as the fuel load was reduced to hold the operating engines at about two thirds maximum power. The specific fuel consumption was assumed to be 0.5 pound per brake horsepower hour.

The gross load at take-off was assumed to be made up of 50,000 pounds empty weight, 2,000 pounds of oil, and 48,000 pounds of fuel and pay load. The curves of figure 35 show the results of the range calculations in terms of pay load plotted against range. The average cruising air speed is taken as 145 miles per hour. This value is somewhat above the speed for maximum range with no wind, but gives about the maximum possible range with a 30-mile-per-hour head wind. The calculated top speed of the seaplane is 168 miles per hour.

It may be noted that a pay load of nearly 14,000 pounds could be carried 2,400 miles against a 30-mile-per-hour head wind. This is about the distance of the longest non-stop flights required for several potential transoceanic air routes. Although this ratio of pay load to gross weight is rather low, the load carried per rated horsepower is about 2.75 pounds, nearly as much as that carried by high-speed-transport land planes.

CONCLUDING REMARKS

The test results of Models 22-A and 35 show that the pointed-step type of hull with low dead rise is capable of giving somewhat better take-off performance than any hull of conventional type so far tested in the N.A.C.A. tank. The lines and data for Model 22-A are applicable to single-hull flying boats, and those of Model 35 to a range of designs including single- and twin-hull flying boats and single-float seaplanes. The low resistance of these hulls, particularly at high speeds, suggests the possibility of increasing the range and pay load of flying boats of clean aerodynamic design, by the use of wing and power loadings higher than those found in current practice.

Wind-tunnel tests to determine the air drag of the pointed-step models, as well as that of a number of models of other types of hull, are in progress and will be reported in the near future.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., July 23, 1934.

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TABLE I

Offsets for N.A.C.A. Model No 22-A Flying-Boat Hull (Inches)

		Distance below base line										Half-breadths					
Sta. No.	Dist. from F.P.	Keel	B 1 [1]1.80	B 2 3.60	B 3 5.40	B 4 7.20	Lower chine	Lower cove	Middle chine	Upper cove	Upper chine	Lower chine & cove	Middle chine & upper cove	Upper chine	W.L.1 [2]10.00	W.L.2 8.00	W.L.3 6.00
F.P.	0	6.00					5.00					0.15					
1/4	1.20	8.77					5.65					1.32				0.23	0.70
1/2	2.40	9.68	6.65				6.25					2.36				.64	1.62
1	4.80	10.74	8.66	7.49			7.33					4.09			0.52	2.08	
1-1/2	7.20	11.32	10.01	8.88	8.25		8.24					5.45			1.56	4.84	
2	9.60	11.67	10.79	9.90	9.24		9.00					6.51			2.94		
3	14.40	11.96	11.49	10.98	10.49	10.10	10.01					7.86			6.85		
4	19.20	12.00	← Elements of Stations Straight lines from here aft →				10.46					8.40					
5	24.00						10.53					8.50					
5a	29.00						10.53					8.50					
6	31.56						10.54	7.60	7.62			8.43	8.50				
7	36.35						10.63	7.69	7.62			7.90	8.47				
8	41.15						10.92	7.98	7.63			6.29	8.32				
9	45.95						11.39	8.45	7.69			3.62	8.04				
10	50.75	12.00 9.06					12.00	9.06	7.77			.15	7.58				
11	55.55								7.89	6.33	6.32		6.83	6.87			
12	60.35								8.07	6.02			5.84				
13	65.15								8.28	5.78			4.62				
14	69.95								8.52	5.62	St. line		3.23	St. line			
15	74.75								8.80	5.52			1.62				
S.P.	78.75	9.06 5.50							9.06	5.50			.15				
T.P.	98.75	2.69									2.63			.15			

[1]Distance from center line (plane of symmetry) to buttock (section of hull surface made by vertical plane parallel to plane of symmetry).

[2]Distance from base line to water line (section of hull surface made by a horizontal plane parallel to base line).

TABLE II

Offsets for N.A.C.A. Model No. 35 Flying-Boat Hull (Inches)

		Distance below base line							Half-breadth								
Sta. No.	Dist. from F.P.	Keel	B 1 [1]1.30	B 2 2.60	B 3 3.90	B 4 5.20	Main chine	Cove	Upper chine	Main chine	Cove	Upper chine	W.L.1 [2]10.00	W.L.2 9.00	W.L.3 8.00	W.L.4 7.00	W.L.5 6.00
F.P.	0	5.00					5.00			Tan. to F.P.							
1/2	1.25	8.35	6.48	5.65			5.60			2.86					0.26	0.85	1.87
1	2.50	9.37	7.67	6.62			6.13			3.85				0.32	1.00	2.00	
1-1/2	4.75	10.33	9.04	7.98	7.30		6.98			4.94			0.37	1.34	2.55	4.82	
2	7.00	10.76	9.82	8.93	8.24	7.77	7.68			5.58			1.04	2.49	4.49		
3	11.50	10.99	10.48	9.91	9.38	8.94	8.65			6.25			2.40	4.97			
4	16.00	11.00	← Elements of stations Straight lines from here aft →				9.14			6.49							
5	20.50						9.29			6.50							
6	25.00																
7	29.50						9.29	6.35	6.35	6.50	6.50	6.50					
8	34.00						9.35	6.41	6.35	6.25	6.25	6.50					
9	38.50						9.56	6.62	6.38	5.48	5.48	6.44					
10	43.00						9.90	6.96	6.41	4.20	4.20	6.25					
11	47.50						10.38	7.44	6.49	2.40	2.40	5.97					
12	52.00	11.00 8.06					11.00	8.06	6.60	.10	.10	5.54					
13	56.80								6.76			4.94					
14	61.60								6.96			4.19					
15	66.40								7.20			3.31					
16	71.20								7.47			2.30					
17	76.00								7.76			1.22					
S.P.	80.00	8.06							8.01			.30					

[1]Distance from center line (plane of symmetry) to buttock (section of hull surface made by a vertical plane parallel to plane of symmetry)

[2]Distance from base line to water line (section of hull surface made by a horizontal plane parallel to base line).

TABLE III

Test Data for N.A.C.A. Model No. 22-A Flying-Boat Hull

Kinematic viscosity = 0.0000140 ft.^{2}/sec.
Water density, 63.5 lb./cu.ft. Water temperature, 52° F.

Note: Positive moments tend to raise the bow

Trim angle, τ = 2°

Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
5	27.3	1.9	-2	0.7
	32.0	2.2	-2	.7
	37.3	2.7	-3	.5
	42.7	3.6	-4	.5
	52.2	4.3	-6	.6
10	27.4	2.9	-1	.8
	32.0	3.4	-2	.7
	37.0	4.1	-4	.7
	42.5	3.9	-5	.6
	52.2	5.1	-7	.7
20	27.5	5.0	6	1.2
	31.8	6.3	3	1.1
	37.2	6.4	0	.9
	42.5	7.2	-3	1.0
	52.2	7.7	-7	.8

Trim angle, τ = 3°

Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
5	21.1	1.3	-2	0.9
	23.1	1.6	-3	.8
	26.2	1.7	-3	.7
	31.2	1.7	-5	.6
	37.3	1.7	-5	.6
	42.2	2.4	-5	.6
	46.5	2.5	-5	.3
	51.5	2.8	-5	.3
10	21.1	2.1	0	1.0
	22.9	2.4	-2	1.0
	26.1	2.7	-4	.9
	31.6	2.1	-5	.7
	36.5	2.4	-5	.5
	37.5	2.8	-5	.7
	42.2	3.0	-6	.5
	46.5	3.5	-6	.3
	51.5	3.9	-7	.5
20	14.2	3.1	16	2.0
	15.9	3.1	14	1.8
	17.6	3.3	9	1.8
	18.8	3.3	8	1.7
	21.0	3.7	7	1.5
	22.9	3.6	3	1.2
	26.5	3.8	3	1.1
	31.7	3.7	-3	.9
	36.6	4.4	-5	.9
	42.0	5.1	-6	.9
	46.5	4.7	-9	.7
	51.5	5.2	-10	.7

Trim angle, τ = 3°

Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
40	6.4	4.9	9	3.8
	7.9	6.1	18	3.6
	9.4	7.0	20	3.3
	11.1	7.8	21	3.2
	12.3	8.5	26	3.1
	13.8	9.6	38	3.0
	16.0	9.2	51	2.9
	17.4	8.4	51	2.6
	18.8	7.8	47	2.6
	21.1	6.6	37	2.1
	23.0	6.4	28	–
	26.3	7.0	21	1.5
	31.7	7.6	11	1.4
	36.9	8.1	3	1.1
	42.0	8.5	-1	1.0
	46.5	8.8	-5	.9
60	6.2	6.8	13	4.5
	7.9	9.6	27	4.5
	9.3	11.4	28	4.3
	26.2	9.9	52	2.1
	31.5	9.8	29	1.7
	37.0	11.2	17	1.3
	42.4	11.9	9	1.4
80	6.2	7.8	9	5.2
	7.9	12.2	30	5.3
100	6.2	9.2	0	5.7
	7.8	14.9	30	5.9

Trim angle, τ = 5°

Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
5	20.4	1.3	-2	0.8
	22.4	1.5	-3	.7
	25.6	1.4	-3	.7
	30.0	1.8	-3	.7
	35.8	2.6	-4	.5
	40.9	2.7	-4	.4
	46.2	3.2	-5	.4
	51.5	3.7	-5	.4
10	20.4	1.9	-2	1.1
	22.4	1.9	-3	1.0
	25.6	2.2	-4	.7
	29.5	2.5	-5	.8
	35.8	3.1	-7	.5
	41.4	3.6	-6	.6
	46.0	4.1	-8	.6
	51.2	4.6	-8	.5
20	11.8	2.5	2	2.2
	13.5	2.7	5	2.0
	14.9	2.7	4	1.9
	17.0	2.9	3	1.9
	18.5	2.8	1	1.8
	20.2	2.9	-1	1.6
	22.4	3.0	-3	1.3
	25.8	3.4	-5	1.2
	29.7	3.6	-8	1.0
	35.8	4.3	-8	1.1
	41.5	4.9	-12	.7
	46.0	5.6	-13	.7
	51.2	6.2	-14	.8

TABLE III (Continued)

Test Data for N.A.C.A. Model No. 22-A Flying-Boat Hull

Kinematic viscosity = 0.0000140 ft.^{2}/sec.
Water density, 63.5 lb./cu.ft. Water temperature 52° F.

Note. Positive moments tend to raise the bow

Trim angle, τ = 5°				
Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
40	7.5	5.2	-1	3.9
	8.9	5.6	3	3.7
	10.2	5.5	5	3.5
	11.9	5.7	10	3.3
	13.5	5.7	23	3.1
	14.9	5.7	31	2.9
	17.1	5.6	23	2.7
	18.6	5.8	18	2.3
	20.3	5.8	12	2.1
	22.4	5.8	7	1.9
	25.4	6.0	1	1.6
	30.8	6.8	-5	1.4
	35.8	7.0	-10	1.3
	41.3	7.6	-15	1.1
	45.8	8.5	-18	.9
60	7.4	8.4	1	4.9
	9.0	10.0	11	4.6
	10.3	10.5	13	4.4
	11.8	11.1	18	4.1
	13.4	11.8	33	4.1
	14.9	12.0	51	3.9
	16.8	11.0	-	3.6
	18.6	9.1	59	3.4
	20.3	8.9	44	2.8
	22.3	8.8	31	2.3
	25.3	8.6	18	2.0
	30.5	9.0	4	1.6
	35.6	9.7	-4	1.6
	41.3	10.2	-13	1.2
80	7.4	10.9	-3	5.5
	9.0	14.5	16	5.5
	10.3	16.9	23	5.3
	11.7	18.1	23	5.1
	13.3	20.0	35	4.9
	22.4	12.0	-	2.8
	25.4	11.7	45	2.4
	30.6	11.7	17	1.9
100	7.5	12.9	-8	6.1
	8.9	17.7	17	6.1

Trim angle, τ = 7°				
Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
5	19.8	1.6	-4	0.7
	21.8	1.7	-5	.6
	23.2	2.0	-5	.6
	26.1	2.3	-6	.6
	30.7	2.7	-7	.5
	35.1	3.4	-8	.4
	39.0	3.9	-9	.4
	43.2	3.4	-12	.2
	49.0	3.3	-13	.1
10	19.8	2.5	-6	1.2
	21.8	2.7	-6	.9
	23.2	2.9	-7	.8
	26.1	3.3	-9	.7
	30.8	3.8	-11	.7
	35.0	4.5	-12	.5
	39.8	5.1	-14	.5
	43.0	5.6	-16	.4
	49.3	6.4	-16	.4
20	14.9	3.2	-5	1.7
	16.8	3.3	-4	1.6
	18.1	3.5	-5	1.6
	19.8	3.6	-6	1.4
	22.0	3.8	-7	1.3
	23.3	4.2	-8	1.3
	26.1	4.6	-11	1.1
	30.2	5.4	-14	1.0
	35.5	6.3	-17	.9
	40.5	6.9	-21	.8
	43.9	7.7	-23	.7
	49.6	8.6	-25	.7
40	5.3	3.5	-35	4.1
	7.2	5.5	-23	3.9
	8.5	5.6	-18	3.7
	10.2	6.1	-14	3.4
	11.4	6.0	-11	3.1
	13.1	6.2	1	2.9
	14.9	6.2	9	2.6
	16.7	6.4	10	2.3
	18.0	6.5	5	2.4
	19.4	6.6	3	2.1
	22.3	6.7	-3	1.7
	23.3	6.5	-5	.9
	26.1	6.9	-7	1.6
	30.2	8.0	-15	1.4
	35.6	9.2	-22	1.2
	40.4	10.0	-27	1.1
	44.0	10.7	-31	.8
60	5.3	4.1	-39	4.7
	7.2	7.8	-28	4.7
	8.6	8.8	-17	4.5
	10.2	9.8	-10	4.3
	11.5	10.0	-3	4.1
	13.0	9.6	7	4.0
	14.9	9.5	30	3.5
	16.7	9.5	38	3.2
	18.0	9.7	29	2.9
	19.5	9.7	24	2.6
	22.3	9.6	9	2.3
	23.5	9.6	6	2.2
	26.2	9.6	-2	1.9
	30.2	9.9	-8	1.7
	35.4	11.6	-20	1.3
	40.0	12.8	-27	1.3
80	5.3	5.3	-43+	5.6
	7.2	9.4	-36	5.4
	8.7	13.0	-14	5.3
	10.1	14.4	-9	5.1
	11.5	15.0	-2	4.8
	12.8	15.5	11	4.6
	12.9	15.6	12	4.8
	14.2	14.9	29	4.5
	14.9	14.8	44	4.5
	16.6	13.9	65+	4.1
	18.0	13.5	64+	3.8
	19.3	13.1	55	3.3
	22.4	13.4	30	2.5

TABLE III (Continued)

Test Data for N.A.C.A. Model No. 22-A Flying-Boat Hull

Kinematic viscosity = 0.0000140 ft.^{2}/sec.
Water density, 63.5 lb./cu.ft. Water temperature 52° F.

Note: Positive moments tend to raise the bow

Trim angle, τ = 7°				
Load lb.	Speed f.p.s.	Resistance lb	Trimming moment lb.-ft.	Draft at step in.
80	23.6	13.0	23	2.4
	26.2	12.7	9	2.3
	30.4	13.1	-1	1.8
100	5.4	5.9	-55-	5.9
	7.1	11.4	-44	6.0
	8.7	16.6	-16	6.0
	9.6	19.2	-6	6.1
	9.9	19.0	-6	5.9
	11.2	20.5	-5	5.8
	12.5	22.2	6	5.6
	14.5	22.1	36	5.4
	16.0	22.7	66-	5.2
Trim angle, τ = 9°				
20	14.5	3.8	-16	1.8
	16.3	4.3	-13	1.8
	18.0	4.6	-13	1.7
	19.5	4.8	-13	1.5
	21.9	5.1	-15	1.3
40	10.2	7.0	-33	3.3
	11.8	6.9	-29	2.9
	12.8	7.1	-20	2.7
	14.7	7.4	-9	2.5
	16.2	7.5	-7	2.4
	18.3	7.4	-6	2.3
	19.3	7.4	-5	2.3
	21.9	7.6	-8	1.7
60	10.1	10.9	-36	4.3
	11.0	10.6	-32	4.0
	12.8	10.7	-17	3.9
	14.8	11.0	2	3.4
	16.4	11.0	9	3.2
	18.0	10.8	10	3.0
	19.8	10.9	4	2.4
	22.0	11.0	-1	2.3
80	10.0	14.3	-40	5.1
	11.2	15.2	-36	5.0
	11.4	15.1	-32	4.8
	12.7	14.3	-15	4.6
	13.2	14.2	-6	4.8
	14.1	14.4	7	4.4
	16.3	14.8	34	4.1
	17.8	15.0	33	3.6
	19.5	14.6	26	3.2
	21.0	14.3	16	2.8
100	9.8	18.1	-44	5.8
	11.1	19.2	-41	5.7
	11.2	19.2	-38	5.5
	12.7	21.3	-2	5.6
	14.2	19.2	17	5.2
	16.1	19.2	53	4.9
	18.2	18.9	65	4.3

Trim angle, τ = 11°				
Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
80	11.8	15.0	-	4.8
	12.7	15.4	-34	4.5
	14.4	16.7	-17	4.1
	14.8	16.7	-11	4.1
	16.4	17.0	1	3.7
100	11.6	20.0	-	5.7
	12.9	19.2	-30	5.5
	14.6	20.5	1	4.9
	16.2	21.6	19	4.6

TABLE IV

Test Data for N.A.C.A. Model No. 35 Flying-Boat Hull

Kinematic viscosity = 0.0000145 ft.^{2}/sec.
Water density, 63.5 lb./cu.ft. Water temperature 50° F.

Note: Positive moments tend to raise the bow

Trim angle, τ = 3°

Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
5	21.7	1.3	-2	1.1
	23.2	1.4	-1	1.2
	26.0	1.6	-2	1.2
	31.2	1.8	-3	.9
	37.2	2.2	-5	.8
	43.2	2.2	-5	.7
	47.0	2.6	-6	.7
	47.6	2.4	-4	.7
	47.8	2.5	-5	.7
	57.0	2.9	-5	.6
10	21.3	1.9	-1	1.6
	23.7	2.3	-1	1.4
	26.7	2.5	-3	1.3
	31.7	2.8	-4	1.2
	36.3	3.3	-6	1.0
	43.1	3.1	-7	.8
	47.9	3.5	-7	.8
	48.2	3.8	-7	.7
	56.4	3.9	-8	.7
20	6.3	1.9	-1	3.3
	8.4	2.4	5	3.2
	10.6	2.7	5	2.9
	12.9	3.0	6	2.8
	14.8	3.1	7	2.7
	17.4	3.6	14	2.7
	19.7	3.4	13	2.5
	21.3	3.7	8	2.3
	23.6	4.1	9	1.8
	26.4	4.0	3	1.7
	31.6	4.6	-1	1.5
	37.0	4.8	-5	1.2
	44.0	5.3	-8	1.2
	46.7	6.1	-10	1.1
	52.7	5.7	-11	.8
	57.6	5.9	-13	.9
40	6.2	3.3	1	4.4
	8.4	5.6	13	4.4
	10.3	6.8	15	4.1
	12.5	7.8	15	3.8
	14.4	8.4	19	3.6
	16.8	9.7	30	3.7
	19.3	10.4	47	3.6
	21.5	10.8	52	3.4
	23.6	9.6	48	3.1
	27.0	8.2	39	2.7
	32.3	8.2	18	2.0
	37.4	8.8	12	1.8
	42.8	8.8	-1	1.5
	47.4	9.1	-6	1.2
	52.6	9.9	-9	1.4

Trim angle, τ = 3°

Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
60	6.2	4.4	-1	5.1
	8.4	8.7	22	5.3
	26.8	18.0	67+	3.5
	31.6	13.0	66	2.8
	37.2	12.1	38	2.3
	43.0	13.1	20	1.8
	47.0	13.1	6	1.7
80	6.1	5.1	-3	6.0
	8.5	11.6	25	6.2
100	6.1	5.5	-2	6.8
120	5.9	6.1	-1	7.4

Trim angle, τ = 5°

Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
5	20.4	1.1	-2	1.2
	22.5	1.3	-3	1.1
	25.2	1.1	-3	.9
	30.9	1.7	-3	.8
	35.0	1.7	-6	.6
	40.1	2.0	-6	.6
	45.0	2.1	-4	.4
	50.4	2.5	-4	.5
	56.0	2.4	-4	.6
10	20.5	1.8	-3	1.6
	22.6	1.9	-4	1.3
	25.2	1.8	-5	1.3
	30.8	2.2	-6	1.0
	35.0	2.7	-8	.8
	40.5	2.7	-9	.9
	44.8	2.7	-8	.6
	50.3	3.3	-10	.7
	56.0	3.3	-6	.7
20	5.7	1.7	-13	3.6
	8.4	2.4	-9	3.3
	9.7	2.3	-9	3.2
	12.0	2.8	-9	2.8
	13.8	2.9	-3	2.7
	16.2	3.0	3	2.5
	18.3	3.0	3	2.4
	20.3	3.2	1	2.3
	22.3	3.2	-1	1.9
	25.2	3.1	-4	1.6
	31.1	3.5	-8	1.4
	35.2	3.9	-10	1.2
	39.5	3.9	-12	1.1
	45.2	4.2	-13	1.0
	51.7	4.2	-12	.9
	56.4	4.9	-15	.9

TABLE IV (Continued)

Test Data for N.A.C.A. Model No. 35 Flying-Boat Hull

Kinematic viscosity = 0.0000145 ft.^{2}/sec.
Water density, 63.5 lb./cu.ft. Water temperature 50° F.

Note: Positive moments tend to raise the bow

Trim angle, τ = 5°				
Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
40	5.7	2.9	-15	4.6
	8.4	5.3	-2	4.5
	9.7	5.7	-1	4.4
	12.1	5.7	-2	4.1
	14.1	5.8	3	3.8
	16.3	6.0	20	3.8
	18.4	6.1	27	3.7
	20.4	5.8	24	3.1
	22.4	6.1	15	2.9
	24.9	5.9	10	2.4
	30.1	6.2	0	2.1
	35.7	6.6	-8	1.6
	39.2	6.6	-13	1.5
	44.1	7.0	-17	1.3
	52.7	7.4	-21	1.3
60	5.9	4.2	-17	5.5
	8.3	8.2	5	5.6
	9.8	9.8	8	5.4
	11.7	11.4	10	5.1
	13.9	12.9	19	4.9
	16.3	13.3	33	4.9
	18.3	12.5	52	4.9
	20.5	12.0	68	4.4
	22.5	9.7	58	3.8
	25.2	9.5	45	3.2
	30.2	9.2	18	2.4
	35.8	10.1	2	2.0
	39.6	9.8	-9	1.8
	44.8	10.4	-16	1.6
80	5.8	5.0	-18	6.4
	8.2	10.8	7	6.5
	9.7	13.5	5	6.1
	11.7	16.9	12	6.0
	25.5	15.4	71+	4.1
	29.7	12.8	52	3.1
	35.4	12.8	23	2.5
100	5.9	5.8	-18	7.2
	8.1	13.3	9	7.3
	9.7	16.7	8	7.0
120	5.9	6.1	-17	7.9
Trim angle, τ = 7°				
5	21.0	1.2	-3	1.1
	21.2	1.2	-3	1.0
	24.3	1.3	-3	.8
	29.7	1.9	-4	.6
	35.0	2.4	-7	.5
	40.8	3.0	-8	.3
	45.0	3.3	-7	.4
	50.0	4.0	-9	.3
	54.4	4.7	-11	.2
10	21.0	2.0	-6	1.6
	21.1	2.0	-5	1.4
	25.0	2.1	-6	1.1
	29.4	2.4	-7	.9
	35.4	3.1	-10	.6
	40.9	3.4	-10	.7
	46.0	4.1	-10	.6
	51.0	4.5	-12	.6
	55.3	5.0	-15	.4

Trim angle, τ = 7°				
Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
20	5.4	1.9	-22	3.6
	7.3	2.7	-19	3.4
	9.5	2.9	-19	3.0
	11.9	3.0	-16	2.7
	13.6	3.1	-15	2.5
	16.1	3.2	-10	2.3
	18.2	3.3	-7	2.2
	20.5	3.4	-6	2.2
	25.0	3.4	-9	1.5
	29.4	3.7	-12	1.4
	35.0	3.9	-13	1.0
	40.3	4.9	-17	1.0
	46.7	5.8	-20	.7
	51.1	6.5	-20	.8
	55.2	7.1	-23	.7
40	5.0	2.5	-33	4.7
	7.4	4.7	-21	4.8
	9.1	5.8	-20	4.5
	9.7	5.8	-19	4.4
	9.9	5.9	-19	4.4
	11.4	6.4	-17	4.2
	13.6	6.0	-13	3.8
	16.0	6.4	-1	3.6
	18.4	6.3	5	3.3
	20.7	6.2	3	3.1
	25.0	6.5	-4	2.3
	29.9	6.6	-12	2.0
	35.3	7.2	-17	1.5
	40.0	7.4	-22	1.4
	45.8	8.1	-25	1.2
	51.1	9.3	-33	.9
60	4.9	3.1	-40	5.7
	7.4	6.7	-20	5.8
	9.1	9.0	-16	5.6
	11.5	10.3	-13	5.2
	13.5	10.9	-1	5.0
	15.6	9.7	12	4.7
	18.4	9.3	32	4.7
	20.7	9.8	30	4.1
	22.1	9.7	27	3.6
	25.3	9.7	10	2.9
	29.5	9.8	-3	2.3
	35.0	10.4	-15	2.0
	40.9	10.6	-24	1.6
	45.8	11.2	-30	1.4
80	4.9	3.4	-42	6.6
	7.3	9.0	-21	6.6
	9.2	12.1	-13	6.4
	11.5	14.9	-7	6.2
	13.6	16.4	5	5.9
	15.7	18.2	31	5.8
	18.4	15.4	55	5.5
	20.3	14.4	66	5.1
	21.9	13.5	69	4.5
	25.5	13.3	34	3.4
	29.3	13.2	13	2.8
	35.1	13.3	-7	2.4

TABLE IV (Continued)

Test Data for N.A.C.A. Model No. 35 Flying-Boat Hull

Kinematic viscosity = 0.0000145 ft.^{2}/sec.
Water density, 63.5 lb./cu.ft. Water temperature 50° F.

Note. Positive moments tend to raise the bow

Trim angle, τ = 7°

Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
100	4.9	3.7	-42	7.4
	7.3	10.8	-21	7.6
	9.1	15.1	-10	7.3
	10.9	18.9	-7	7.0
	13.2	22.5	11	6.8
	15.4	28.6	53	7.0
	18.3	25.0	69	6.4
	20.4	23.6	72+	6.1
	22.0	21.1	72+	5.5
	25.2	17.3	70+	4.2
120	5.0	6.2	-36	8.2
	7.2	12.5	-18	8.3
	9.1	18.4	-8	8.1
	11.1	22.8	-3	7.8

Trim angle, τ = 9°

Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
20	6.4	2.9	-27	3.7
	8.8	3.6	-25	3.4
	9.9	3.7	-26	3.0
	11.9	3.7	-27	2.7
	14.4	3.8	-22	2.4
	16.4	4.0	-19	2.4
	19.1	3.9	-17	2.2
	20.4	4.0	-14	2.0
40	6.2	4.3	-37	5.1
	8.6	6.4	-36	4.7
	10.0	7.1	-32	4.5
	12.0	7.1	-27	4.2
	14.4	7.2	-22	3.7
	16.9	7.1	-15	3.7
	18.5	7.2	-14	3.2
	20.9	7.4	-11	2.9
60	6.2	5.6	-44	6.0
	8.5	9.0	-35	5.9
	9.7	10.0	-34	5.6
	12.1	11.2	-23	5.3
	14.1	10.7	-14	4.8
	16.8	11.2	-1	4.7
	18.8	11.2	3	4.1
	21.1	11.1	3	3.7
	23.0	11.3	-2	3.4
	26.3	11.2	-8	2.9
80	6.1	6.5	-45	7.0
	8.5	11.1	-34	6.9
	9.6	13.0	-33	6.6
	11.9	15.0	-30	6.2
	14.0	16.7	0	6.1
	16.8	15.0	18	5.6
	19.0	15.1	27	5.0
	21.1	15.3	27	4.5
	23.5	15.1	21	4.0
	27.0	15.0	5	3.3
100	6.0	7.0	-45	7.8
	8.6	13.6	-30	7.6
	9.6	15.6	-31	7.5
	11.9	19.6	-10	7.2
	13.9	21.9	7	7.1
	17.3	21.1	39	6.6
	18.5	20.2	53	6.3
	20.3	20.0	63	5.6
	23.5	19.3	50	4.7
	27.0	18.9	33	3.8
120	6.1	12.1	-40	8.9
	8.6	18.9	-18	8.8
	9.6	21.3	-19	8.7
	11.9	26.1	-3	8.3

Trim angle, τ = 11°

Load lb.	Speed f.p.s.	Resistance lb.	Trimming moment lb.-ft.	Draft at step in.
60	10.8	12.5	-40	5.6
	14.1	13.1	-31	4.9
	15.8	13.0	-27	4.5
	17.8	13.0	-22	4.1
	20.0	13.1	-22	3.8
80	10.9	15.6	-42	6.6
	13.3	18.1	-22	6.2
	15.4	17.4	-14	5.5
	17.8	17.4	-7	4.9
	20.0	17.2	-6	4.5
100	10.9	19.4	-36	7.6
	13.4	22.1	-14	7.2
	15.4	21.7	3	6.7
	17.8	22.0	15	5.9

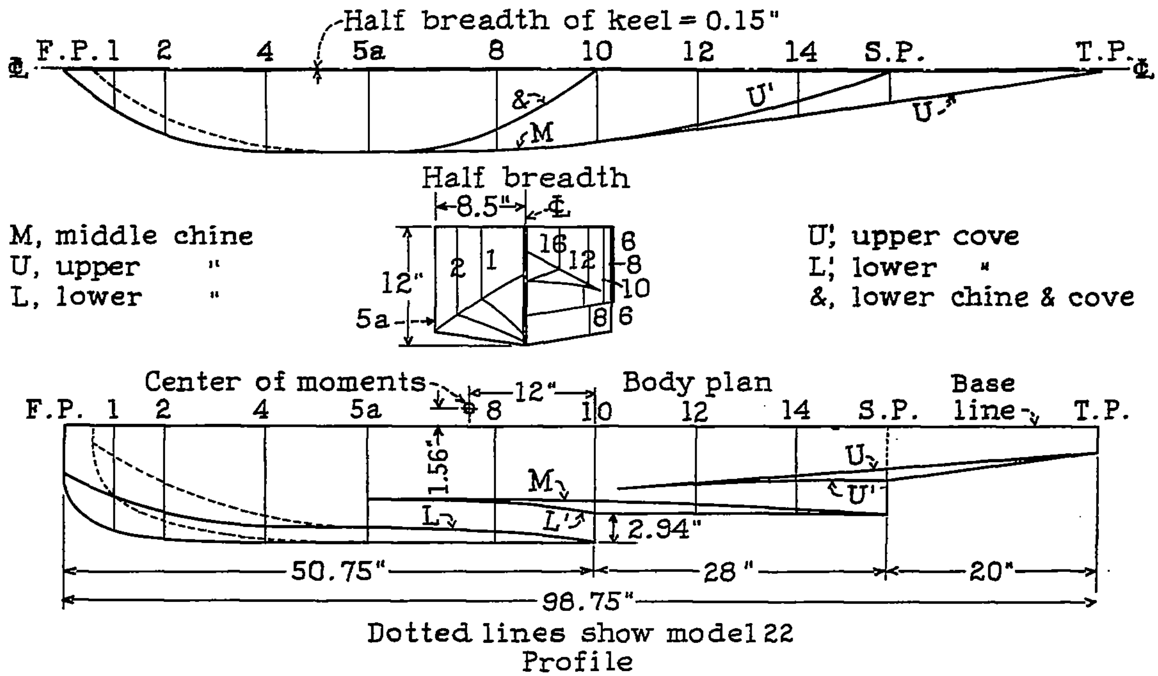


Figure 1.- Lines of N.A.C.A. model 22-A

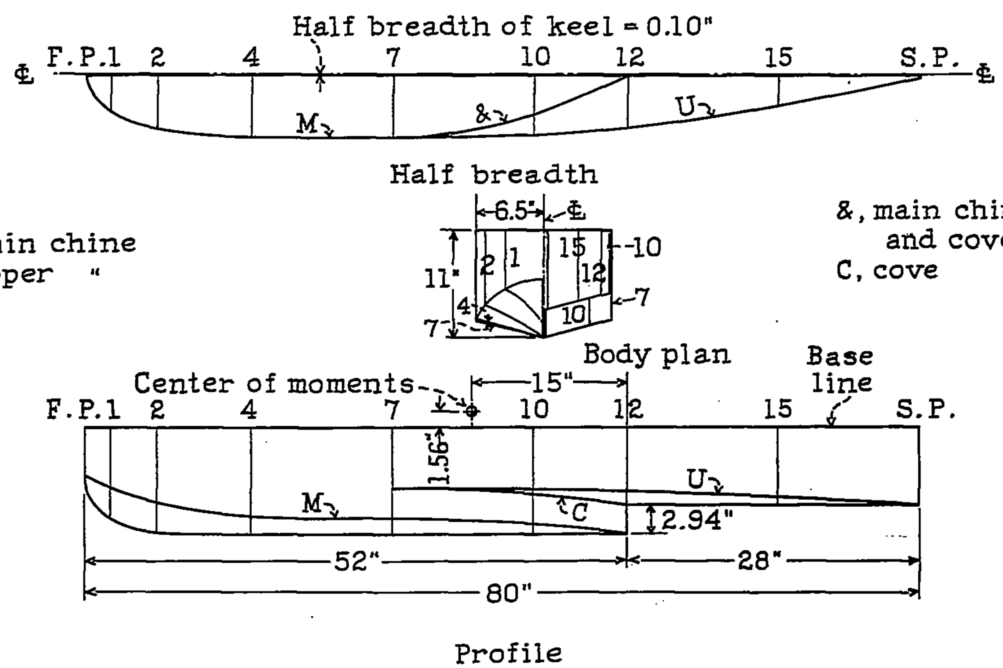


Figure 2.- Lines of N.A.C.A. model 35

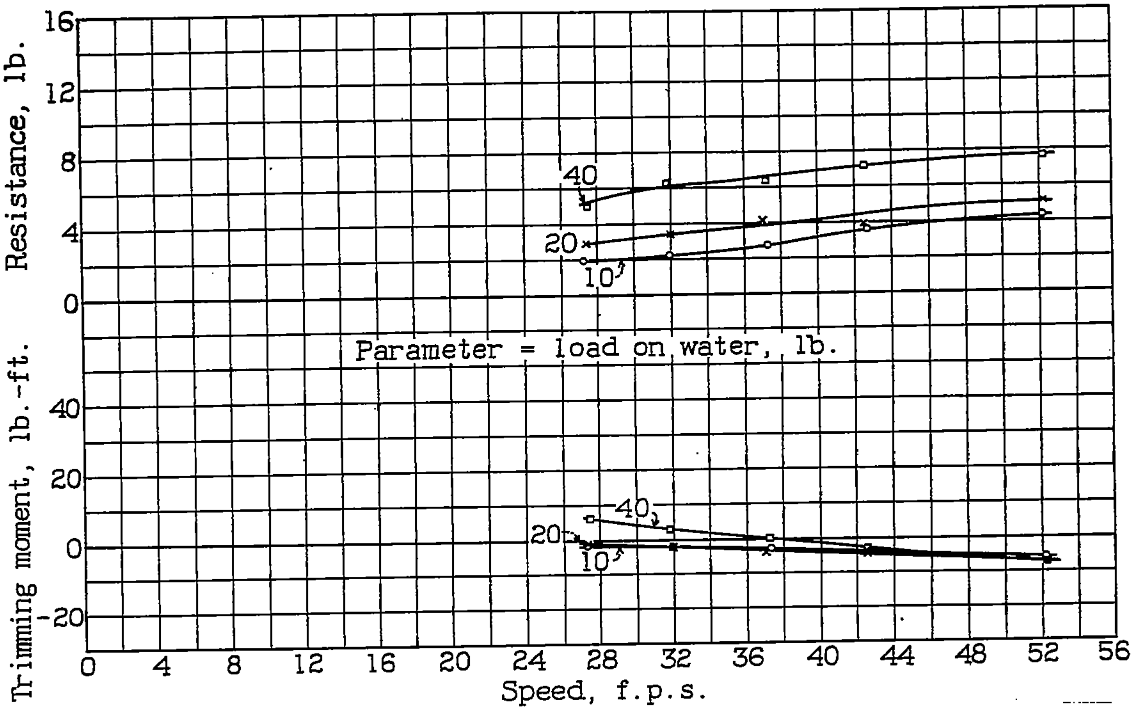


Figure 3.- Resistance and trimming moment, τ=2°. Model 22-A

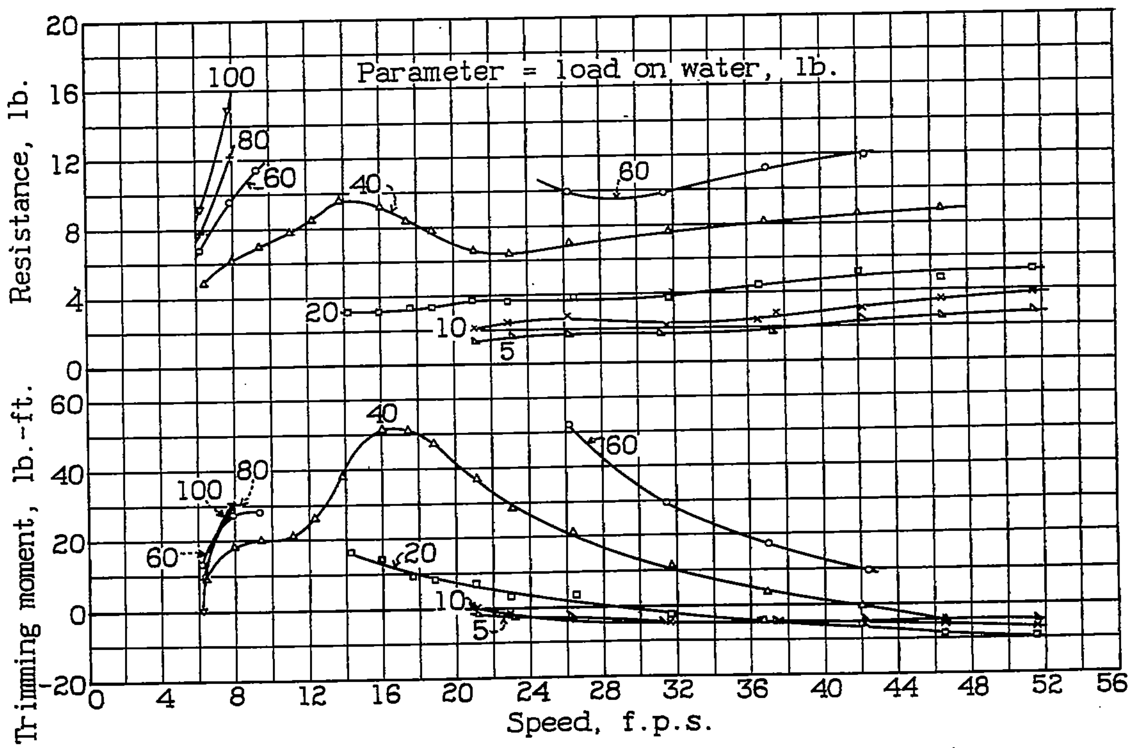


Figure 4.- Resistance and trimming moment, τ=3°. Model 22-A

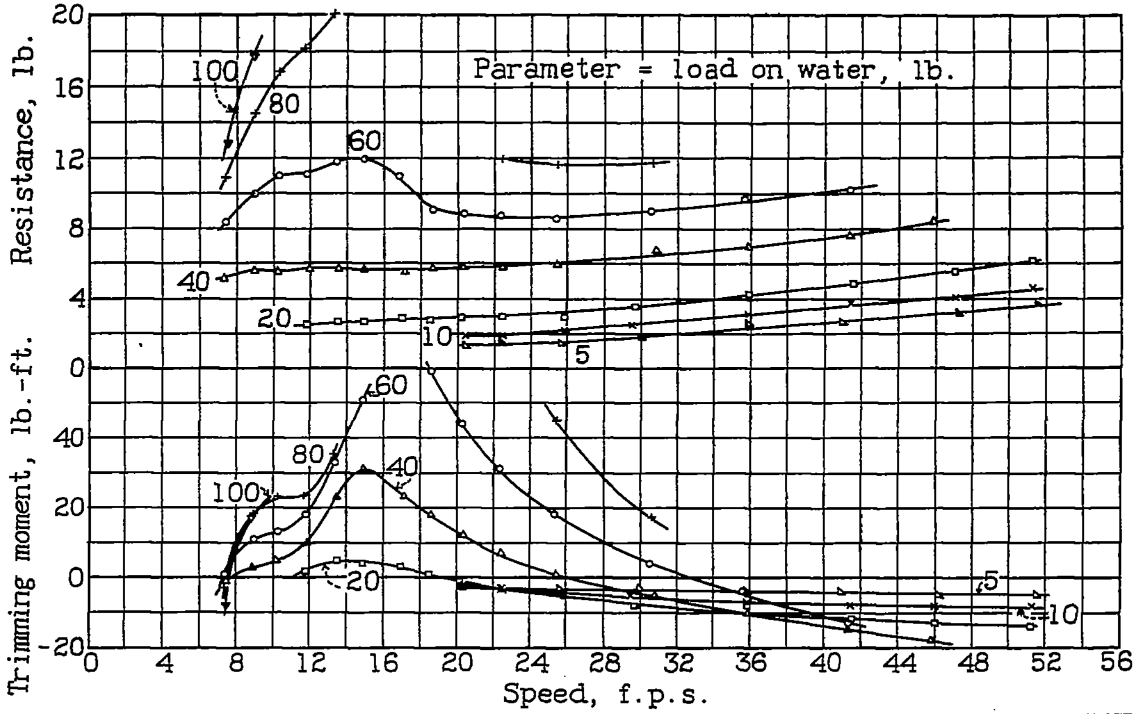


Figure 5.- Resistance and trimming moment, τ=5°. Model 22-A

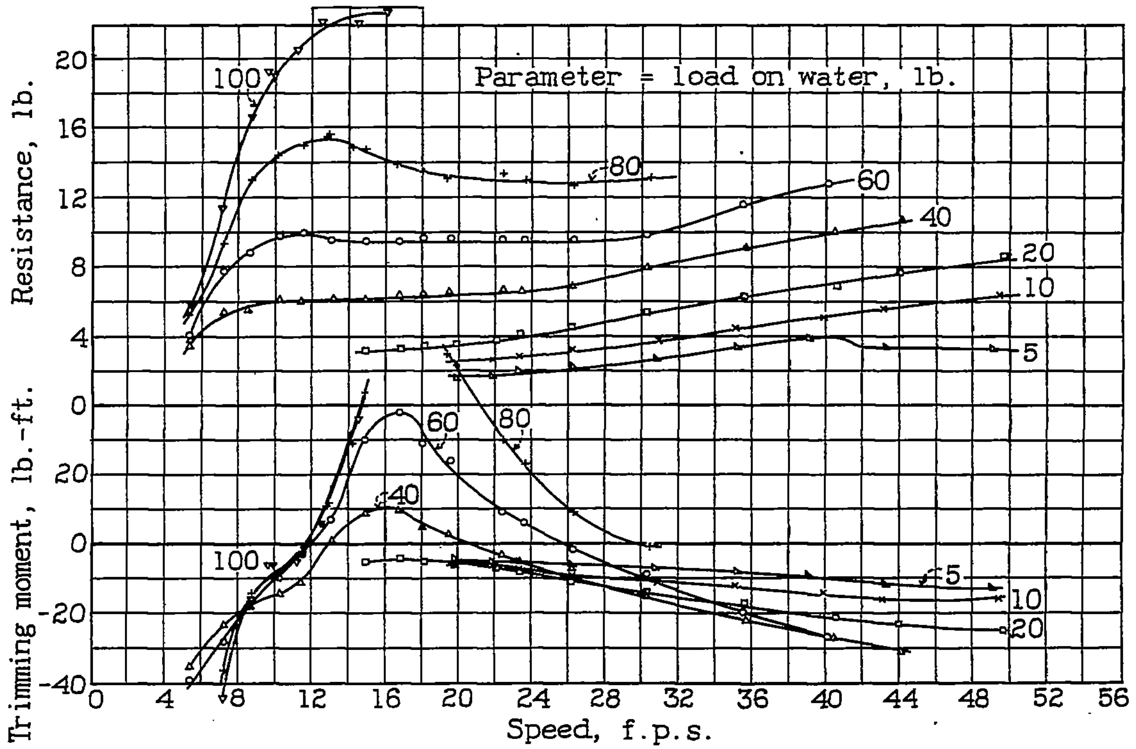


Figure 6.- Resistance and trimming moment, τ=7°. Model 22-A

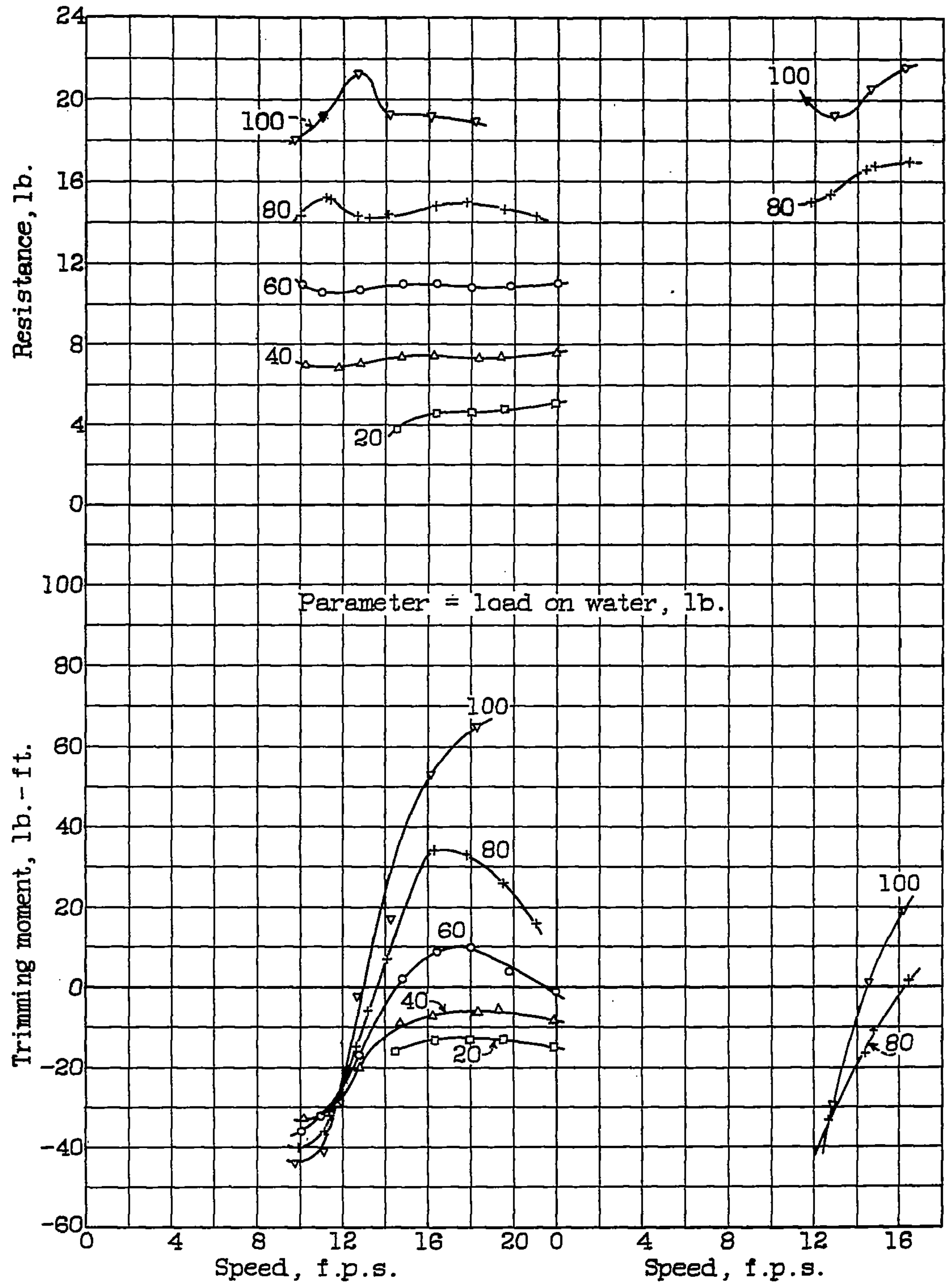
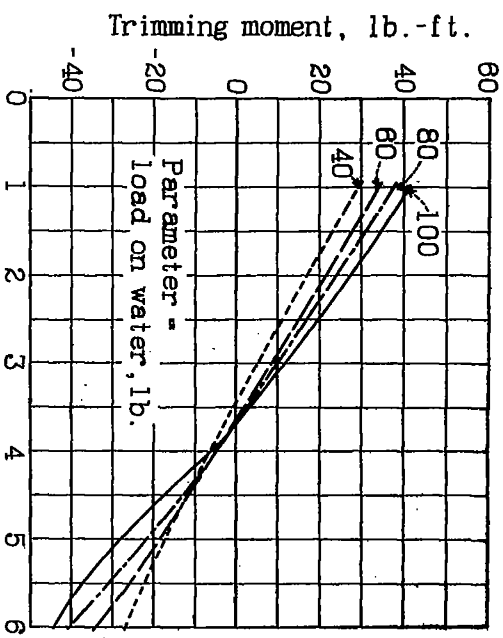


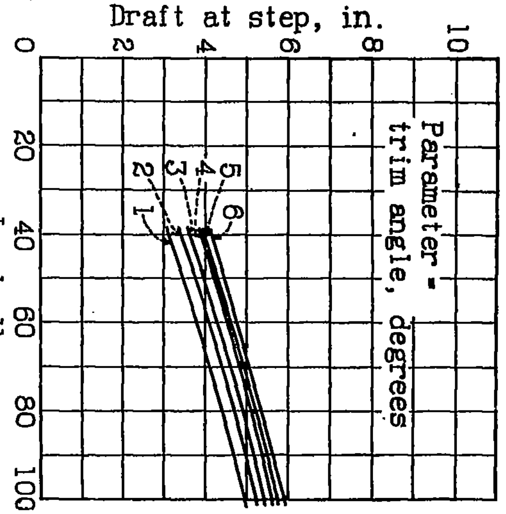
Figure 7.- Resistance and trimming moment. τ = 9°. Model 22-A.

Figure 8.- Resistance and trimming moment. τ = 11°. Model 22-A.



Trim angle, degrees

Figure 9.- Trimming moments at rest. Model 22-A.



Load, lb.

Figure 10.- Drafts at rest. Model 22-A.

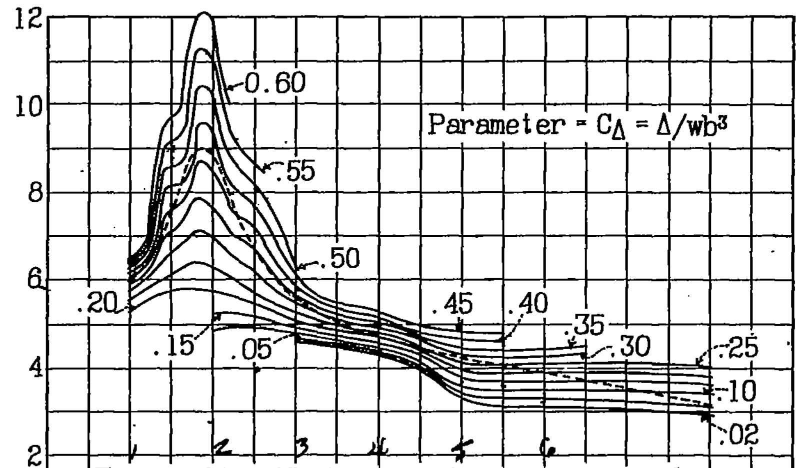


Figure 11.- Variation of best trim angle, τ_o, with C_V. Model 22-A

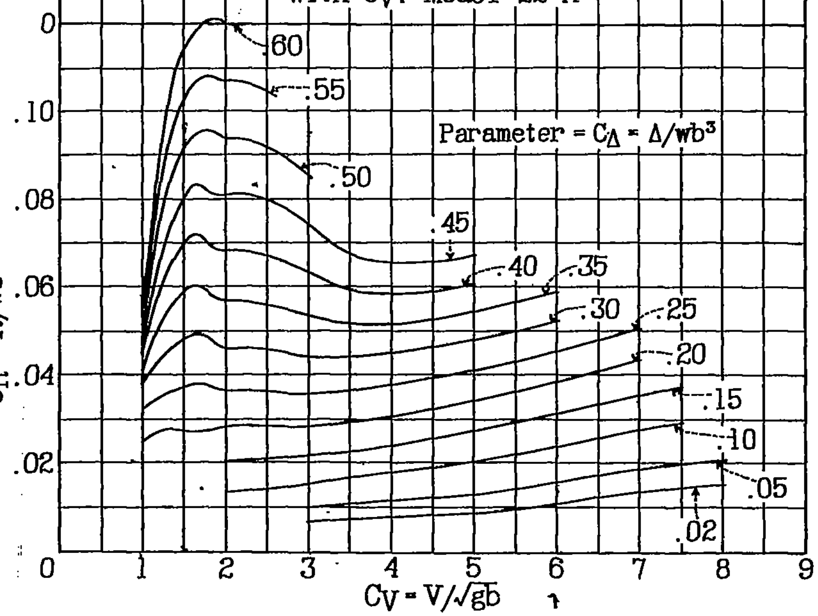


Figure 12.- Variation of C_R with C_V at best trim angles. Model 22-A

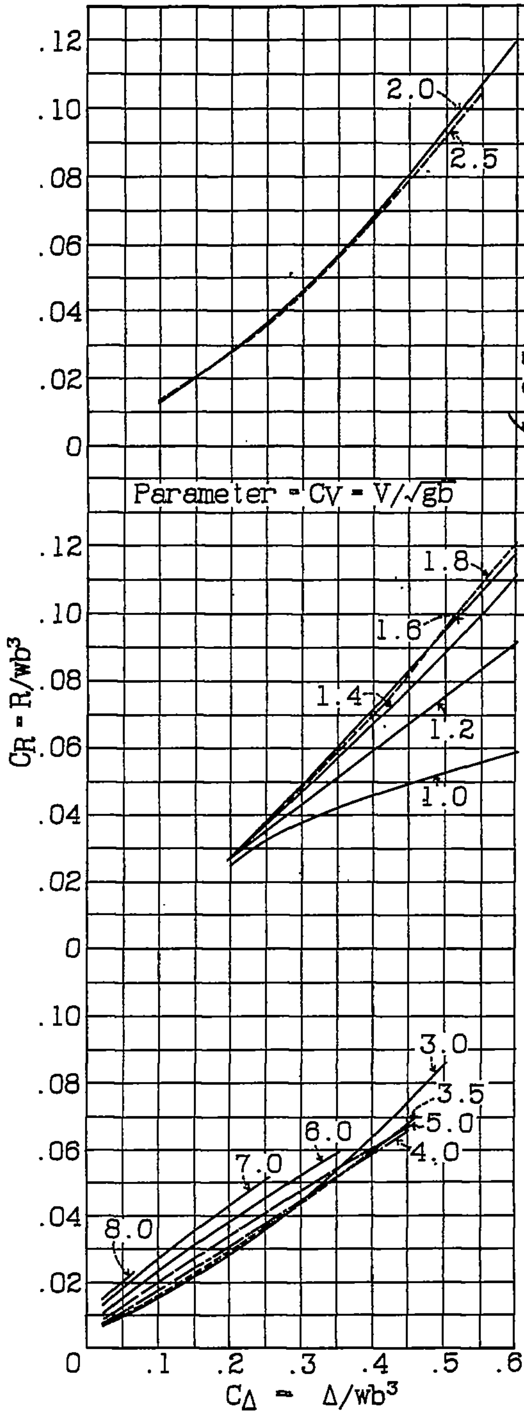


Figure 13.- Variation of C_R with C_Δ at best trim angles. Model 22-A

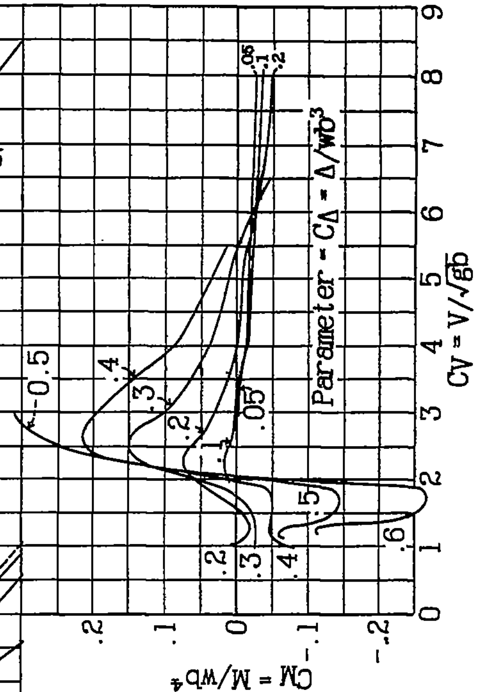


Figure 14.- Variation of C_M with C_Δ at best trim angles. Model 22-A

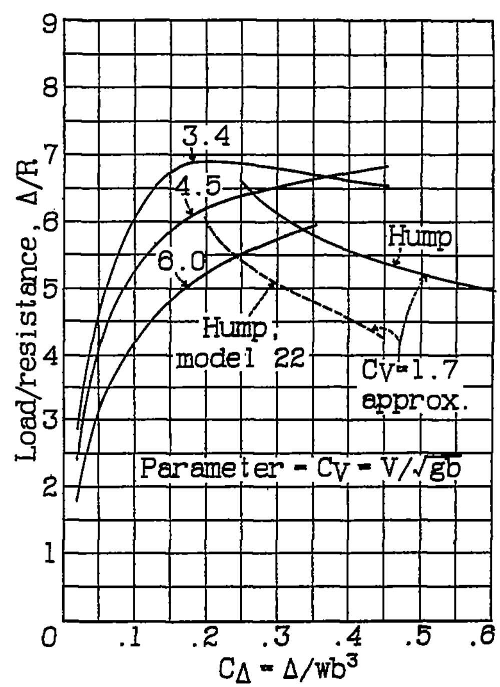


Figure 15.- Variation of Δ/R with C_Δ at best trim angles. Model 22-A

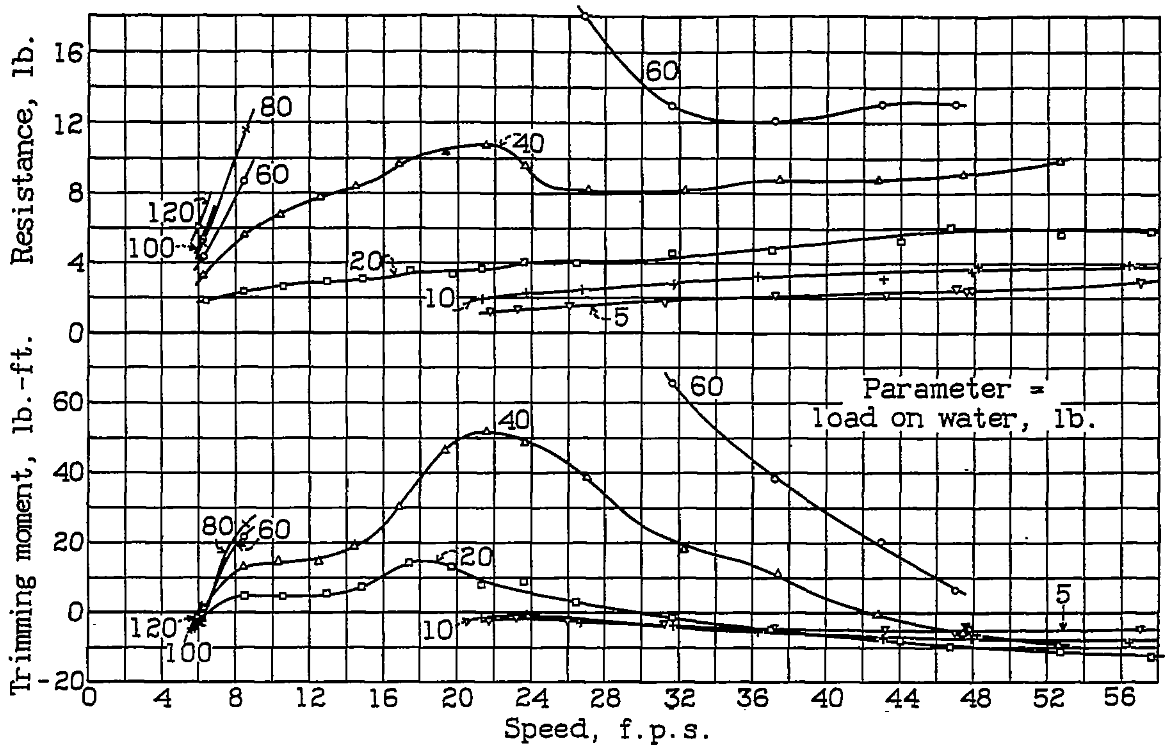


Figure 16.- Resistance and trimming moment, τ=3°. Model 35

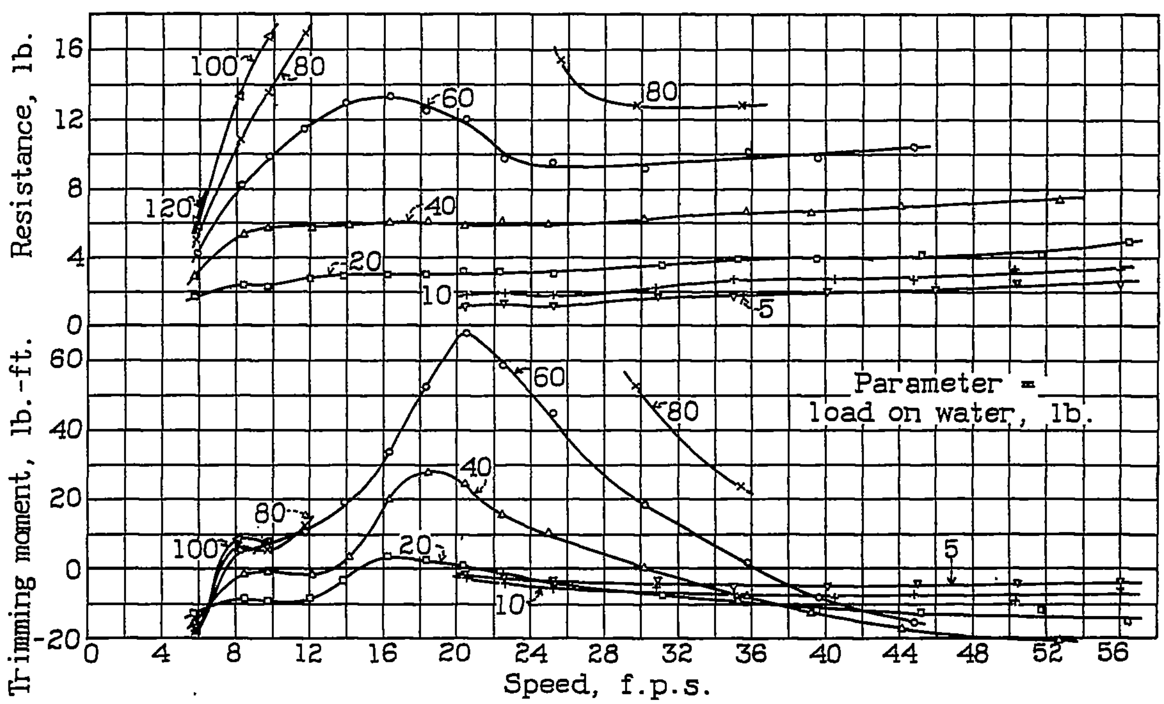
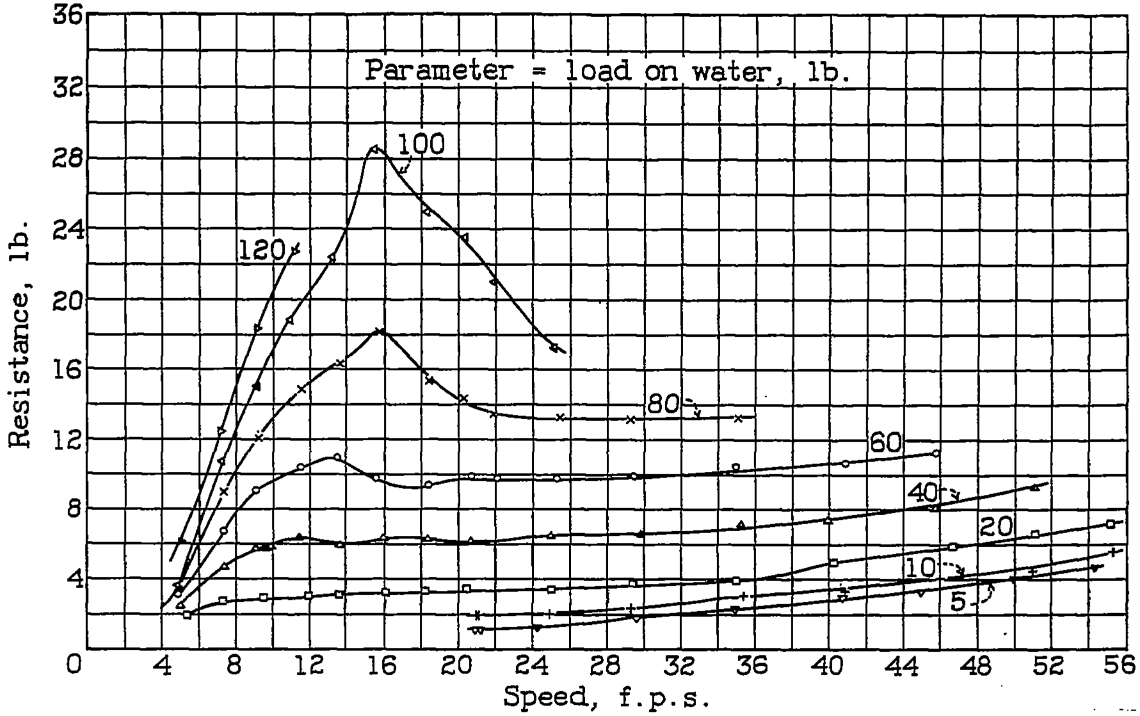


Figure 17.- Resistance and trimming moment, τ=5°. Model 35



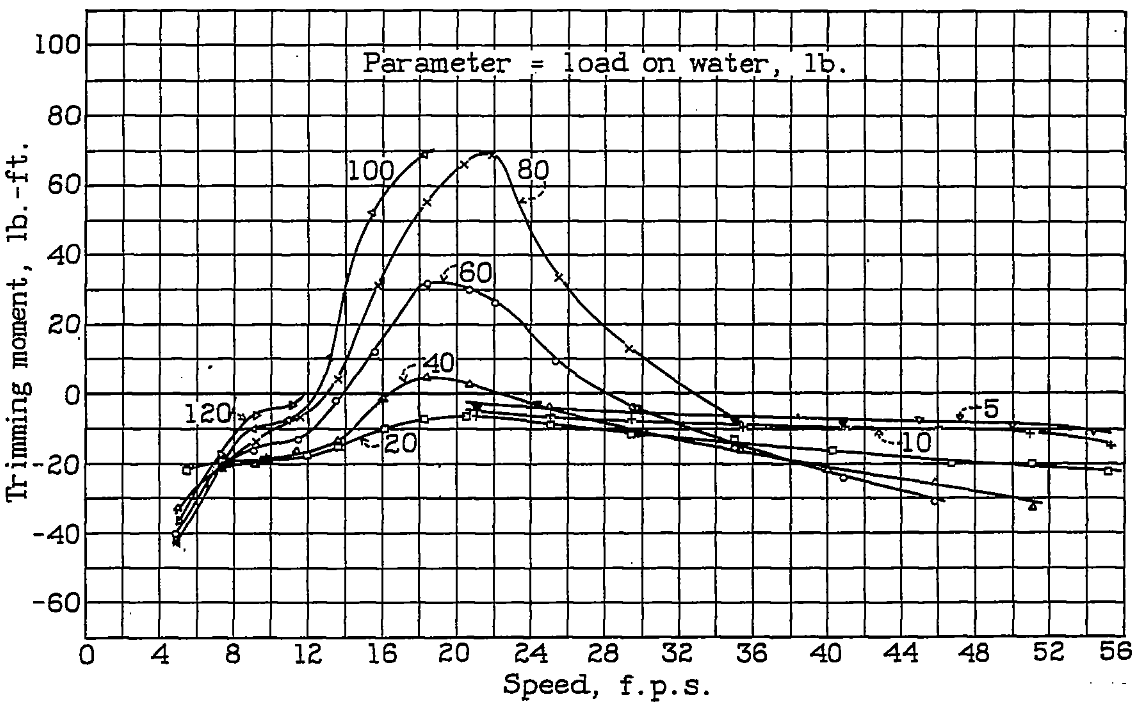


Figure 18. - Resistance and trimming moment, $\tau = 7°$. Model 35

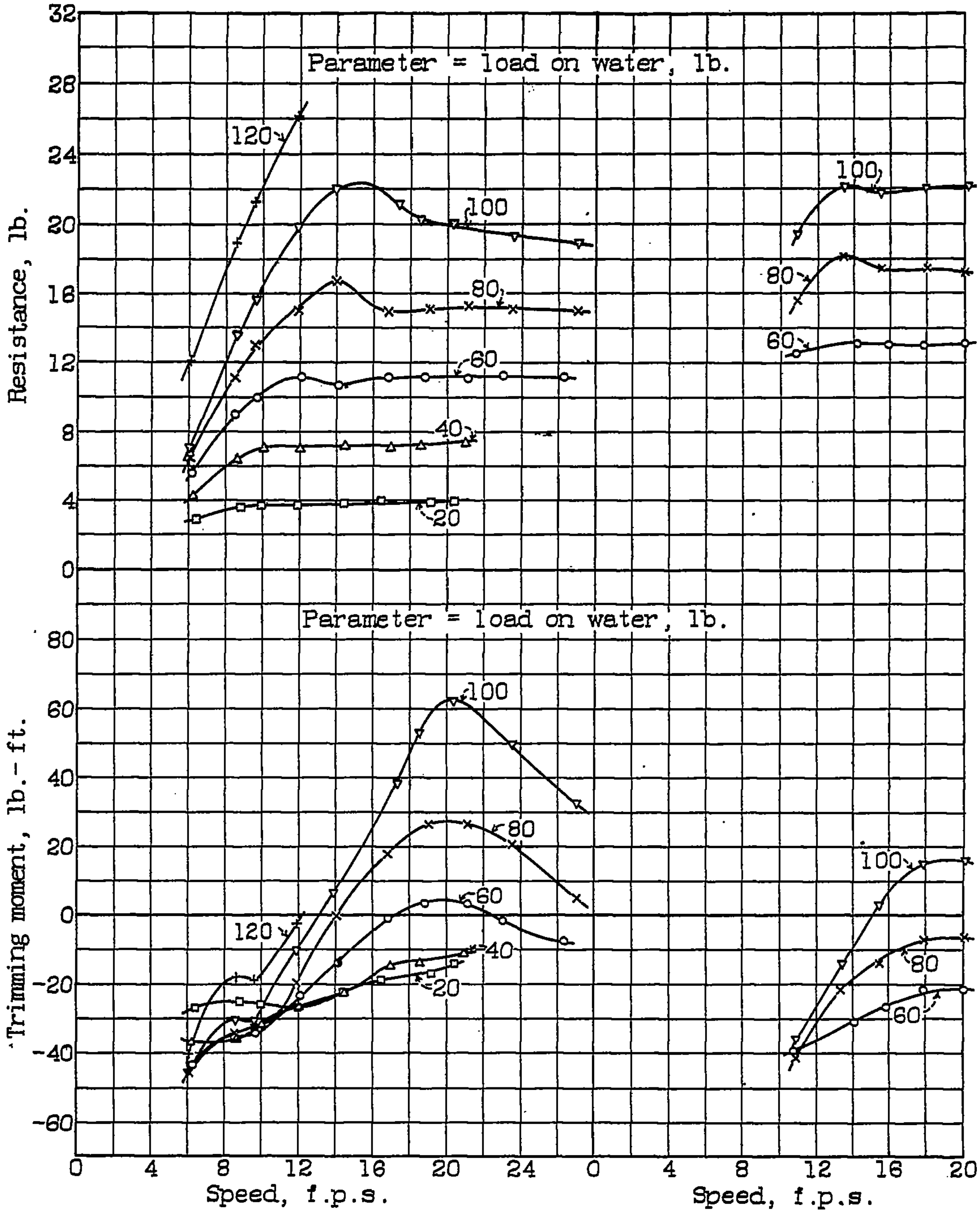


Figure 19.- Resistance and trimming moment, τ = 9°. Model 35.

Figure 20.- Resistance and trimming moment, τ = 11°. Model 35.

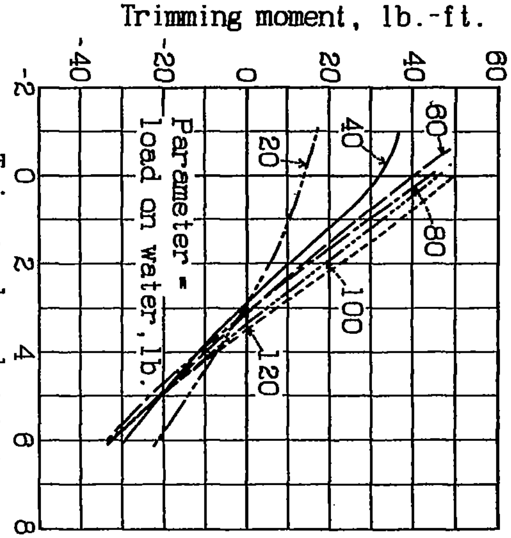


Figure 21. - Trimming moments at rest. Model 35.

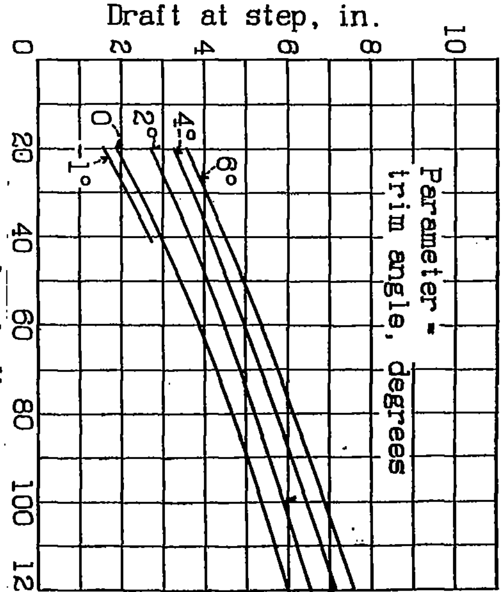


Figure 22. - Drafts at rest. Model 35.

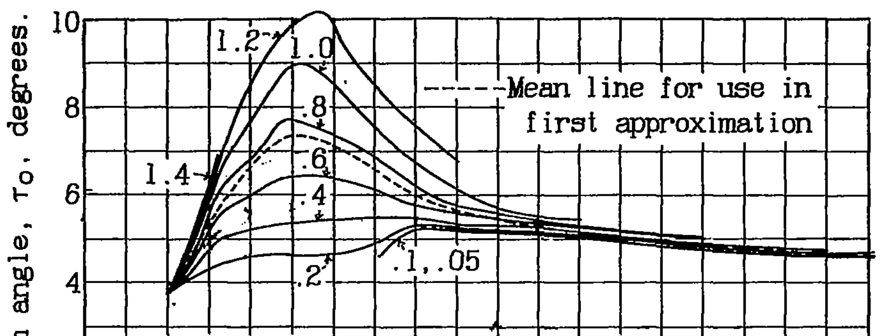


Figure 23.- Variation of best trim angle, τ_o, with C_V. Model 35.

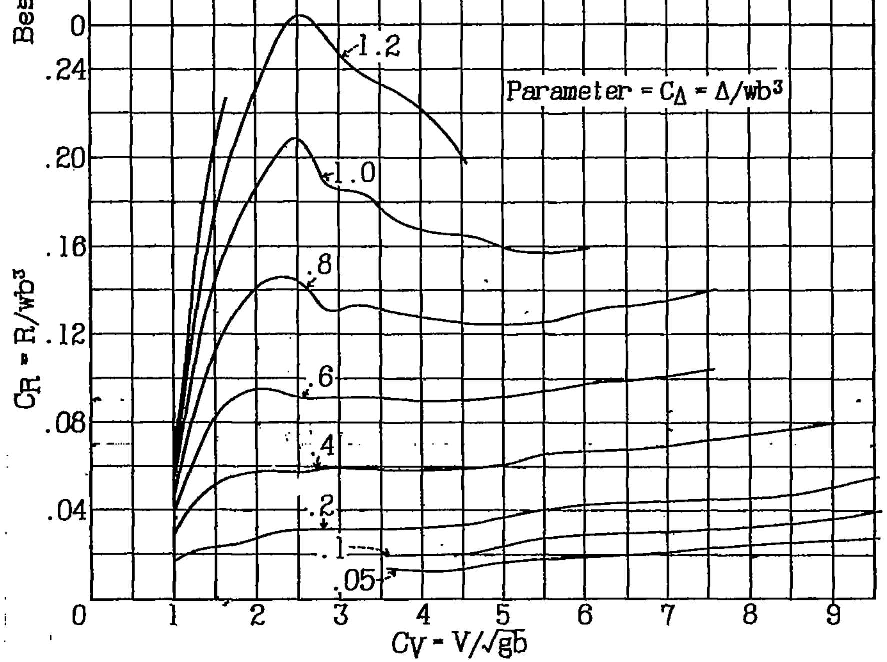


Figure 24.- Variation of C_R with C_V at best trim angles. Model 35.

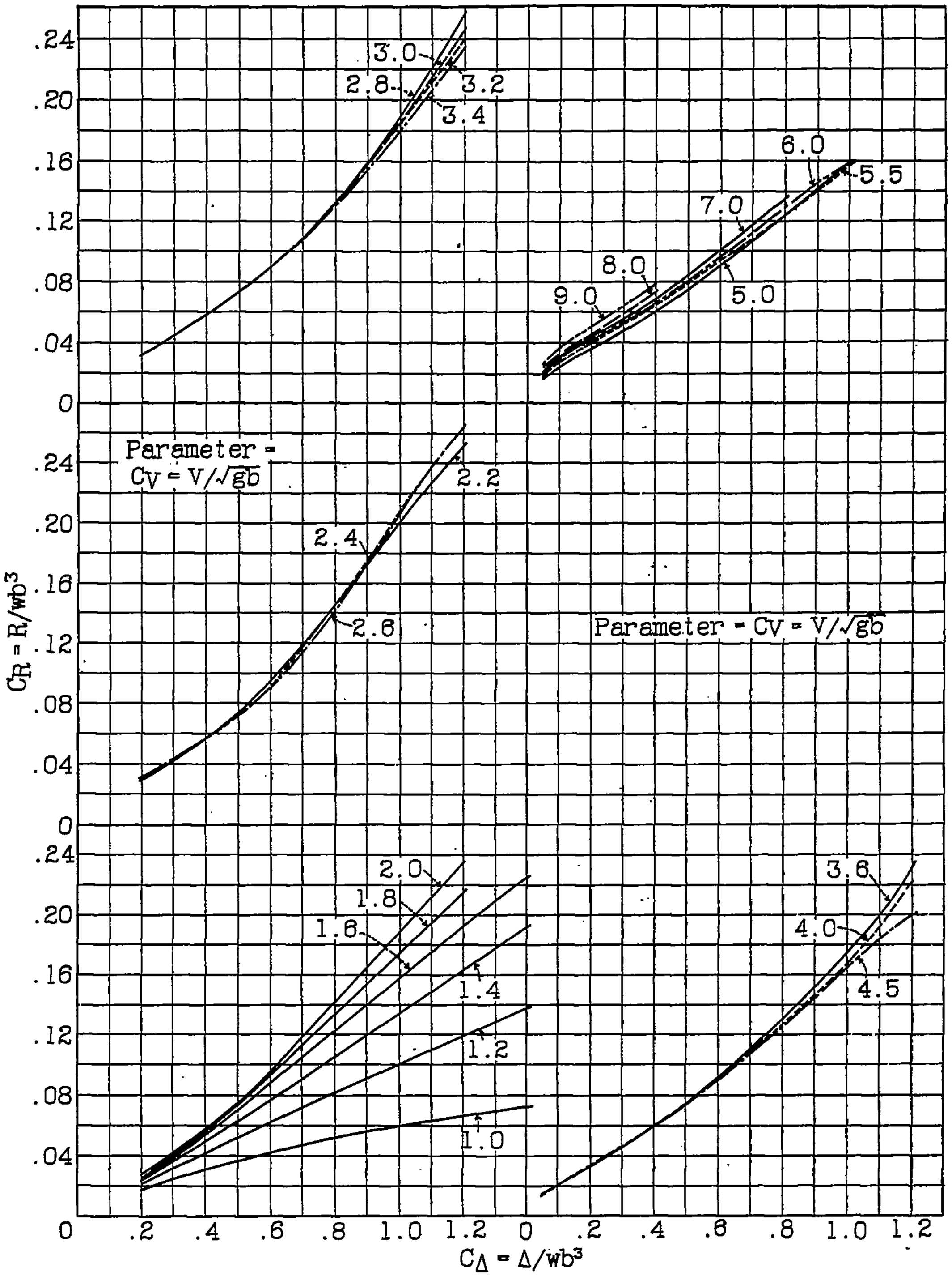


Figure 25a. Figure 25b.

Figures 25a & 25b.- Variation of C_R with C_Δ at best trim angles. Model 35.

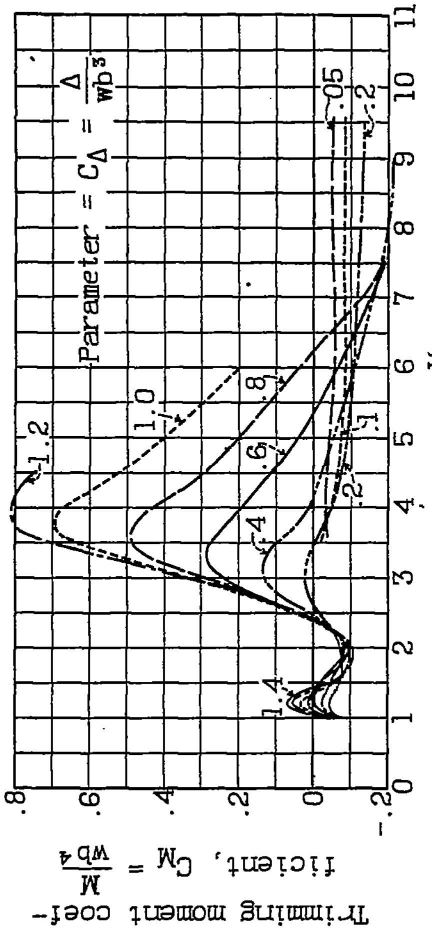


Figure 26.- Variation of C_M with C_V at best trim angles. Model 35.

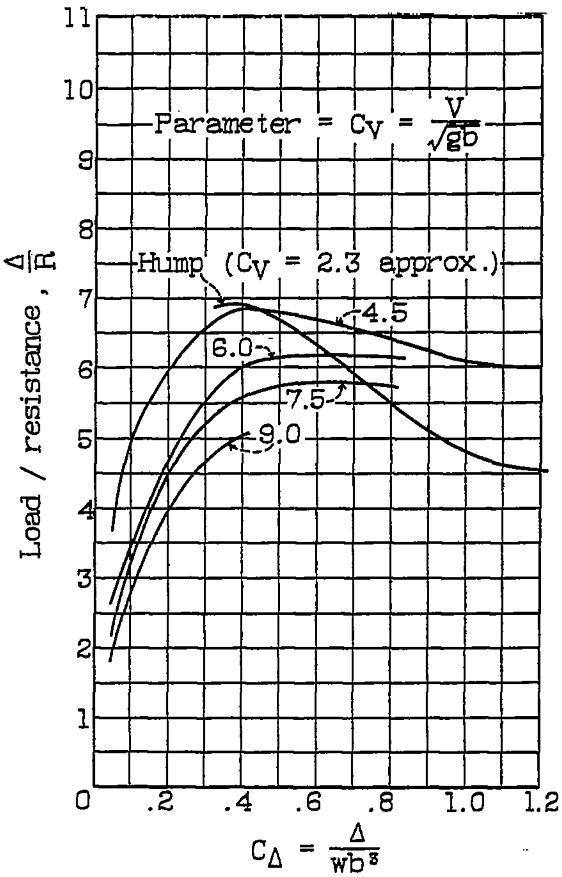


Figure 27.- Variation of Δ/R with C_Δ. Model 35.

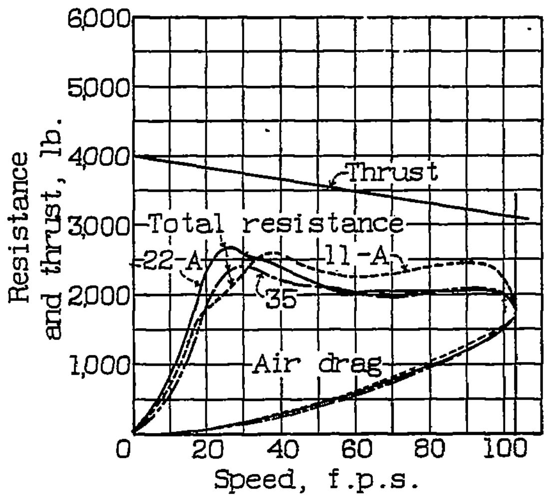


Figure 28.- Thrust and resistance of 15,000 lb. flying boat.

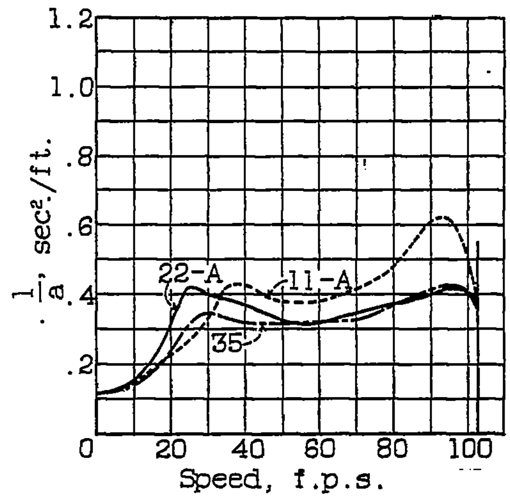


Figure 29.- Curves for determination of take-off time of 15,000 lb. flying boat.

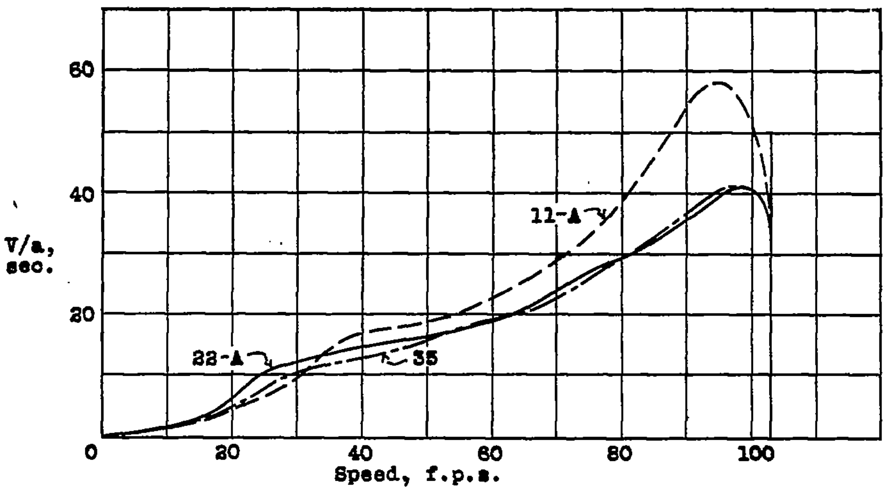


Figure 30.- Curves for determination of take-off run of 15,000 lb. flying boat.

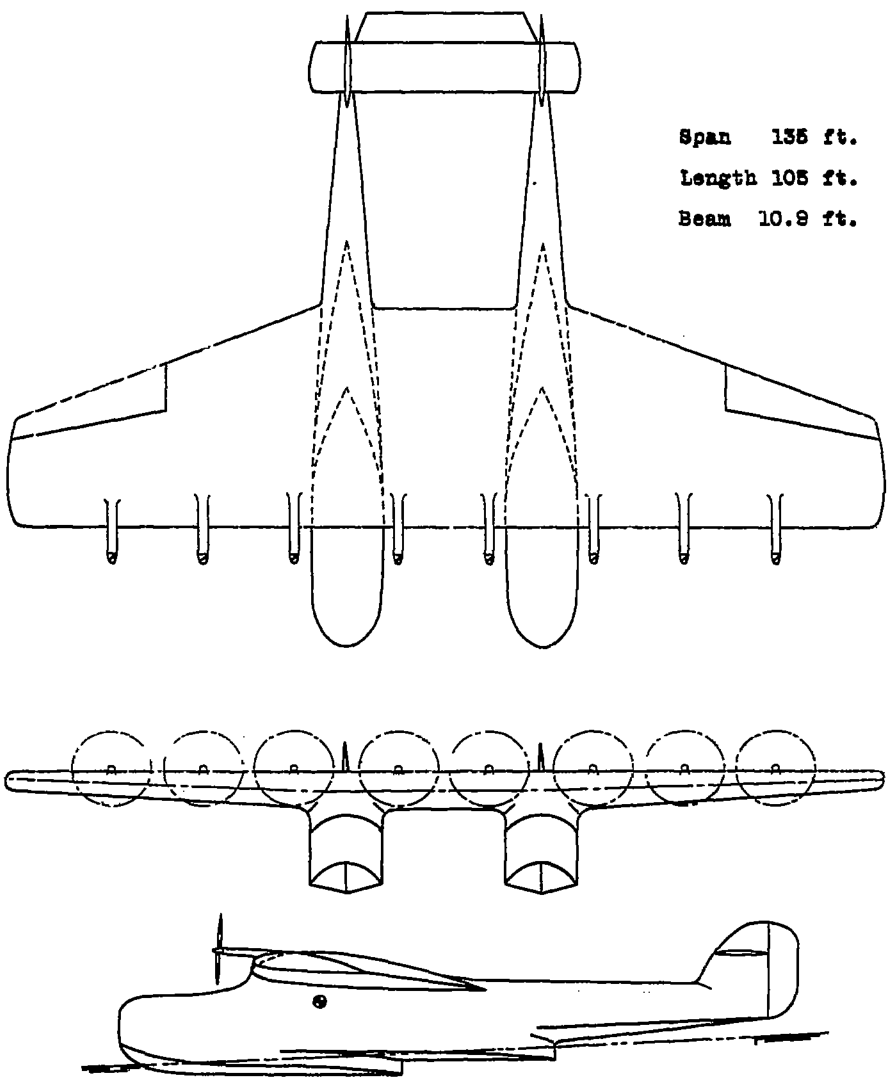


Figure 31.- Hypothetical 100,000 lb. flying boat using Model 35 hulls.

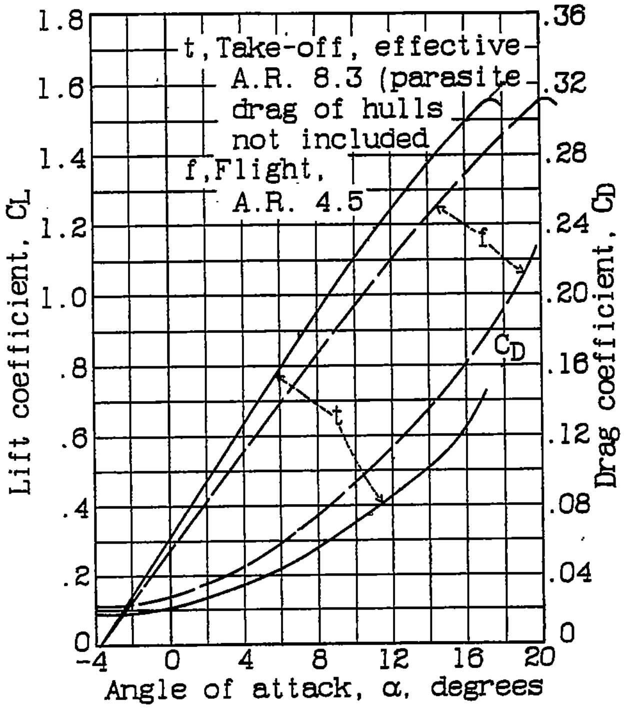


Figure 32.- Lift and drag of 100,000 lb. flying boat.

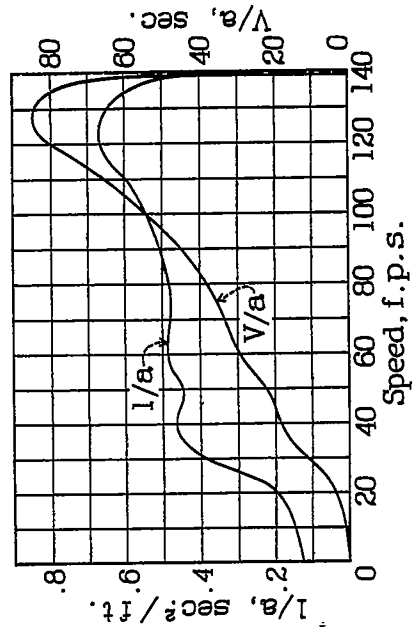


Figure 34.- Curves for determination of take-off time and run of 100,000 lb. flying boat.

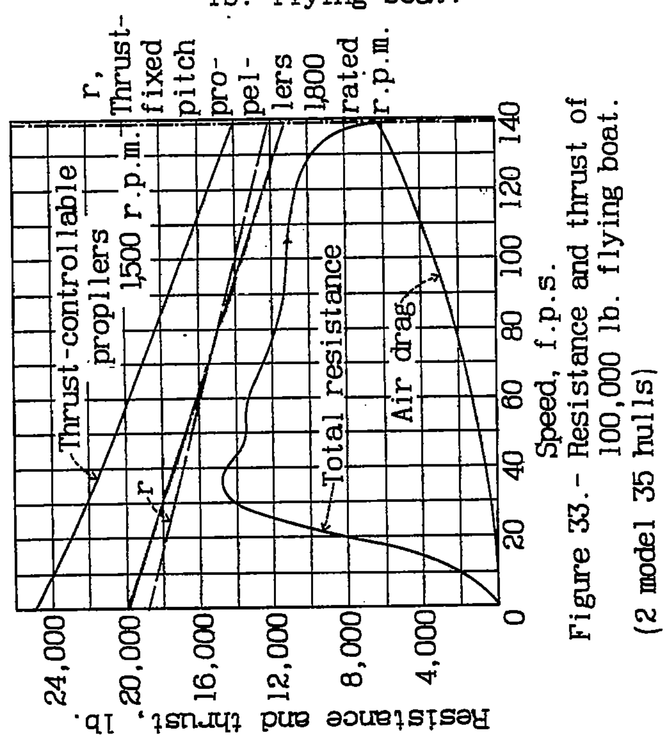


Figure 33.- Resistance and thrust of 100,000 lb. flying boat. (2 model 35 hulls)

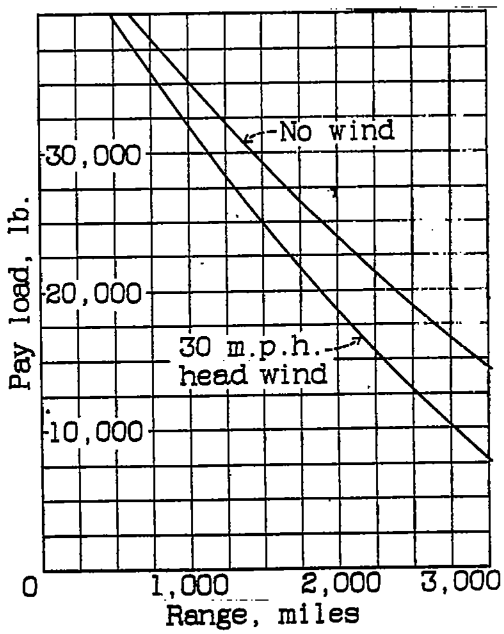


Figure 35.- Variation of pay load with range, 100,000 lb. flying boat.